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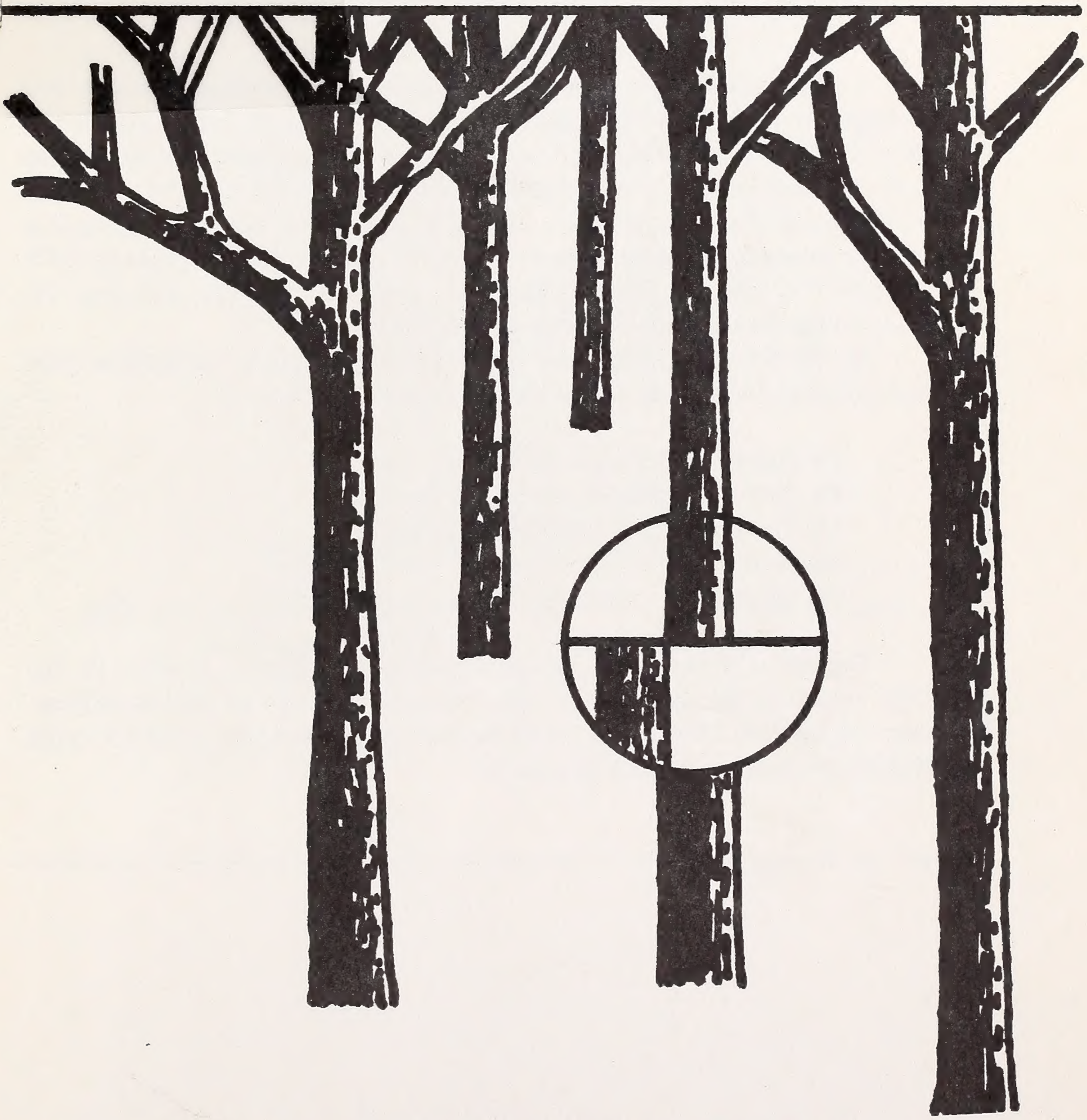
Timber Volume Determination with Multi-Stage Sampling



The Application of 3-P Sampling and the STXMOD Program

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The Application of 3-P Sampling and the STXMOD Program

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Compiled
By
C.R. Chehock
Forest Management Systems Specialist

USDA Forest Service, Southeastern Area, State and Private Forestry
1720 Peachtree Road, NW, Atlanta, Ga. 30367

ABSTRACT

A practical and time-saving procedure is presented using tree content and value estimates with multi-stage sampling, coupled with standing tree dendrometry for determining various product volumes and/or values for continuous forest inventory (CFI) and timber volumes for sale. The flexibility of computer program STXMOD and subsampling with 3-P provides a wide range of sampling designs and field procedures.

CONTENTS

INVENTORY DESIGN AND STATISTICS

A forest inventory should be designed to provide accurate information and should do so at the least possible cost. Generally, the more accurate the inventory, the more measurements that must be taken; however, a compromise is possible through a trade-off between accuracy and cost.

It is usually best to begin the design of an inventory by setting down all the information that is ultimately desired. Then, within cost limits, the inventory should be designed to collect the data which will provide this information. Except for small areas, it is usually impossible to visit and accurately measure every tree in the forest, so some sort of sampling must be employed.

In sampling, each population or stratum of a population has certain statistics defining its variability. Some of the basic terms of statistics and formulas are:

Mean. – One of the most familiar and commonly estimated population parameters is the *Mean.* Given a simple random sample, the population mean is estimated by:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

where: X_i = The observed value of the ith unit in the sample.
n = The number of units in the sample.

$\sum_{i=1}^{n} X_i$ means to sum up all "n" of the X values in the sample.

Standard Deviation. – Characterizes the dispersion of the individuals about the mean. It gives us some idea whether most of the individuals in the population are close to the mean or spread out. On the average, about two-thirds of the unit values of a normal population will be within 1 standard deviation of the mean. About 95 percent will be within 2 standard deviations and about 99 percent within 2.6 standard deviations. We will seldom know or be able to determine the standard deviation exactly. However, given a sample of individual values from the population, we can make an estimate. For a simple random sample of "n" units, the formula is:

$$SD = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}}$$

Where: $\sum X^2$ = the sum of squared values of all individual measurements.
$(\sum X)^2$ = the square of the sum of the measurements.

Example: Ten trees of the same species were selected at random and measured. These diameters were 9, 11, 10, 8, 7, 7, 6, 12, 10 and 9 inches. Based on this sample, the arithmetic mean diameter and standard deviation is:

	X	X^2
	9	81
	11	121
	10	100
	8	64
	7	49
	7	49
	6	36
	12	144
	10	100
	9	81
Sum	89	825

$$\text{Mean} = 89 \div 10 = 8.9$$

$$SD = \sqrt{\frac{825 - \frac{89^2}{10}}{9}}$$

$$\sqrt{\frac{32}{9}}$$

$$1.91$$

Coefficient of Variation. – In nature, populations with large means often show more variation than populations with small means. The *coefficient of variation* (CV) facilitates comparison of variability about means of different sizes. The CV is the ratio of the standard deviation to the mean. A standard deviation of 2 for a mean of 10 indicates the same relative variability as a standard deviation of 16 for a mean of 80. The coefficient of variation would be 0.20 or 20 percent in each case. In the problem discussed above, the coefficient of variation would be estimated by

$$CV = \frac{SD}{\overline{X}} * 100 = \frac{1.91}{8.9} * 100 = 21.48\%$$

Standard Error of the Mean. – The individual units of a population usually vary. The standard deviation is a measure of this variation. Because the individual units vary, variation may also exist among the means (or any other estimates) computed from samples of these units. Take, for example, a population with a true mean of 10. If we were to select four units at random, they might have a sample mean of 8. Another sample of four units from the same population might have a mean of 11, another 10.5, and so forth. Clearly it would be desirable to know the variation likely to be encountered among the means of samples from this population. A measure of the variation among sample means is the standard error of the mean. It can be thought of as a standard deviation among sample means; it is a measure of the variation among sample means, just as the standard deviation is a measure of the variation among individuals. The standard error of the mean may be used to compute confidence limits for a population mean.

The computation of the standard error of the mean depends on the manner in which the sample was selected. For simple random sampling without replacement (i.e., a given unit cannot appear in the sample more than once) from a population having a total of N units, the formula for the estimated standard error of the mean is:

$$SE_{\bar{x}} = \sqrt{\frac{SD^2}{n}\left(1 - \frac{n}{N}\right)}$$

In the problem discussed, we had n = 10 and found that SD = 1.91 or $SD^2 = 3.65$. If the population contained 1,000 trees, the estimated mean diameter ($\overline{X}$ = 8.9 inches) would have a standard error of:

$$SE_{\bar{x}} = \sqrt{\frac{3.65}{10}\left(1 - \frac{10}{1000}\right)}$$

$$= .60$$

Application of the Statistics Calculated

For a sampling design, we are most concerned with the coefficient of variation (CV). The coefficient of variation is formally defined as the ratio of the standard deviation to the mean of the population, and is thus a measure of the relative variability of the population. In other words, the lower the coefficient of variation, the less variable the population. In random sampling, the number of samples that must be taken for a given precision is directly related to the CV according to the formula:

$$n = \frac{t^2 CV^2}{E^2}$$

where: n = number of samples needed
t = student's statistics at a given level of probability (approximately 1 for 67 percent level of probability and 2 for 95 percent level of probability)
E = desired sampling error expressed as a percent of the mean.

Thus, if it is desired to sample a forest with a CV of 100 percent to a 10-percent sampling error 95 times out of a 100 (t = 2), the number of samples needed would be:

$$n = \frac{2^2 * 100^2}{10^2} = 400$$

The above formula shows that doubling the precision of an invenry will require four times as

many samples. The formula also infers that a 10-percent sampling error at a 95-percent probability level is equivalent to a 5-percent sampling error at the 67-percent level.

Where more than 5 percent of the area is occupied by sample units, a "finite population correction" factor can be employed to reduce the number of sample units required, as suggested by Freese (1967, pages 12 and 13). However, sample units usually account for less than 5 percent of the area in forest inventories.

We are seldom interested in just one parameter in forest inventory, but in designing an inventory, the CV for the most important parameter to be sampled, for instance, cubic-foot volume is usually picked as the basis for computing the number of samples needed. Remember, the use of this one CV may result in greater or smaller sampling errors on other parameters, depending on their own CV's.

Coefficients of variation can be estimated from old inventories or cruises, or a small initial sample can be taken to estimate CV. However, the estimate of CV should be based on the same sampling scheme to be employed in the inventory (that is, the same plot radius or basal area factor should be used).

On a small area where each tree can at least be visited, if not measured, trees to be measured can be selected randomly or by use of 3-P sampling. When trees are selected randomly, the CV is based on the variation in volume from tree to tree. In 3-P sampling, where the volume of each tree is guessed, the CV is based on the variation in the ratio of actual to estimated volume (see Forest Service Research Paper PSW-21, pp. 25-29).

On larger areas, some form of sampling must be used that doesn't involve visiting each tree. The two methods usually employed are fixed- and variable-radius plot sampling. Fixed-radius plots can be quite efficient in sampling even-aged stands where all trees are about the same size. However, care must be used to select the size of plot. Because fixed-radius plots sample too many small trees and not enough large trees, they are generally less efficient in sampling for volume than are variable-radius plots. However, in some cases, it is desirable to sample a large number of smaller trees (for example, in a forest where many trees are just becoming merchantable); fixed-radius plots would be suitable there. It is also quite common to use a fixed-radius plot for small-diameter trees (5 to 6 inches [13 to 15 cm] and less) and sample large trees on a varaible-radius plot, both with the same plot center.

Variable-radius plots are highly efficient in sampling for volume because trees are picked with a probability proportional to their basal area, which alone is usually a good predictor of volume. Variable-radius plots are usually most efficient in sampling uneven-aged stands, or in forests with a wide variation in size classes. A basal area factor should be chosen which gives an average count of about seven to ten trees per point.

Three-P subsampling can be used with either fixed-radius plots or variable-radius points to provide an even more efficient and accurate sample. The formula given previously is used to determine the number of 3-P sample trees necessary, but here we are concerned with the coefficient of variation of the ratio of the calculated cubic volume to the estimated diameter at breast height (d.b.h.) squared, times height (D^2H) or estimate volume of the tree, and the sampling error desired on the 3-P subsample. The CV of this ratio is normally in the order of 15 to 25 percent. Thus, for a coefficient of variation of 20 percent, and a desired sampling error of 2 percent (two times out of three), 100 3-P sample trees would be needed. This sample should be increased somewhat to take care of possible variation in sample size. When permanent plots are used, the number of sample trees should be increased to allow for the loss of trees over a period of time as a result of cutting or mortality. The additional number of trees required depends on both the length of rotation and the length of time before the inventory base is reestablished. The shorter the rotation, the faster the sample trees will be cut; the longer the inventory cycle, the more trees that will be needed to still have an adequate sample at the end of this period.

Three-P sample trees are selected by generating a list of random numbers from 1 to

"KZ" and selecting trees whose predicted volume (or height for variable-radius plot sampling) is equal to or greater than a paired random number. This results in a sample of trees proportional to their predicted volume or height, hence "probability proportional to prediction", or 3-P sampling. KZ is determined simply by dividing the actual or estimated sum of all predictions (total volume on all plots or sum of all heights on all prism points) by the desired number of samples. Because the largest volume or height in the population (called "K") is known, or can be estimated, random numbers larger than this will never select sample trees. These numbers can be considered as nulls, and any trees paired with these nulls will be rejected as samples. However, if any trees do occur which are larger than "K", they are selected and measured as sure-to-be-measured trees. This error can occur because of the lack of knowledge of the largest trees, but it is also often desirable to separate, and 100 percent measure, very large trees from the sample to prevent bias.

Because the procedures described here can be used with almost any sampling scheme, it is usually fairly easy to convert an existing inventory system to one employing 3-P sampling and dendrometry. All that is usually necessary is to select a 3-P subsample from the inventory, dendrometer the sample trees and use the STX computer program to compile the data.

ALTERNATIVE SAMPLING SCHEMES

Three-P sampling and the STX computer program provide wide latitude in inventory design. If the number of trees is small, every tree may be visited. On larger areas the first-stage sample may be plots of any size or variable-radius plots of any basal area factor. Sophisticated sampling designs may involve three or more sampling stages, incorporating aerial photo plots or subsamples of selected plots, points or geographic areas. These additional sampling stages may be equal-probability samples, or may themselves be 3-P samples. Strata with differing intensities of sampling of differing plot sizes can be combined in a single inventory. Inventories may be stratified by species, d.b.h., geography, or any other scheme. Any species, product, or grade codes may be used. Some of the alternative sampling schemes available to the user of the STX program are as follows:

Dendrometry of a subsample of plots or points. – It may be desirable to limit dendrometry of sample trees to a subsample of the first stage of plots or points. On these points or plots, either all trees or a 3-P selected sample of trees may be dendrometered. The advantage of not having to visit so many plots must be weighed against limiting the 3-P sample trees to only part of the first-stage population.

Selection of sample areas for further subsampling. – First-stage sample areas may be selected based on areas delimited by photo interpretation or from reconnaissance cruises or inventories. If it is possible to deliminate areas with approximately equal total volume (not area), areas to be subjected to further sampling may be selected with equal probability. If this is not possible, the total volume of the first-stage areas should be estimated and sample areas selected by 3-P sampling. Either method will serve to reduce first-stage sampling variation. The areas selected may be inventoried by visitation of all trees, with trees 3-P sampled for dendrometry on all or part of the plots or points.

Photo-point sampling. – Volume per acre may be guessed at randomly located photo-points. Points to be measured on the ground may be

selected by 3-P sampling and, in turn, the trees on these points may be subjected to 3-P sampling to select trees for dendrometry, or a sample tree is selected at each sample point by $H/\sum H$, following the procedure discussed by Chehock (1980).

Ground-point sampling. – Like photo-point sampling, an estimate of volume per acre may be made at ground points, from which plots to be subjected to further measurement may be selected using 3-P sampling. Either all or a 3-P subsample of the trees on these plots may be dendrometered.

Other sampling schemes. – Any sampling scheme involving up to three sampling stages can generally be handled by the STXMOD program. More complicated sampling schemes can be handled by calculating frequencies or blow-up factors of some of the stages by hand or by another computer program and incorporating them in the program control card fields. Grosenbaugh (1974) gives a complete discussion of possible multistage sampling techniques and the capabilities of the STXMOD computer program.

LAYOUT AND ESTABLISHMENT OF SAMPLE POINTS FOR CFI

The coefficient of variation of the sample, and consequently the number of samples needed, can be greatly reduced by delineating permanently nonstocked or nonproductive areas such as roads, open fields, lakes, rivers, etc. The net forest area to be sampled can then be determined by subtracting the nonforest area from the total land area. Sampling can also be more efficient if similar areas can be stratified and sampled separately.

From a statistical point of view, sample points should be selected randomly. However, a true random distribution of points over an area is difficult to achieve and most sampling schemes use some sort of systematic sample as a base. In the most common case, the net forest areas is divided by the number of samples needed to determine the area represented by each point. A grid which will provide the right sampling frequency can then be determined and constructed. This grid is then overlaid on a map with a random starting point and a random orientation. Sample points are established by pricking through the grid onto the map.

This technique may be modified to provide a more random sample by constructing a grid that will provide some multiple of the actual number of points required. Then select the actual points through the use of random numbers. For instance, a grid which would provide 10 times as many samples as needed might be used, with one out of 10 points selected at random for measurement. The smaller the grid used, the more nearly point selection would be completely random. As would be expected, this procedure is more costly.

Another technique is to select points at random using map coordinates. Degrees of latitude and longitude, metric grids, or any other coordinate system can be used if available. Random numbers for either of these methods can be generated by the RN3P computer program.

Once the plots have been located on a map it is often desirable to transfer them to aerial photos, if available, to aid in locating the plots in the field. The plots are established on the

ground by scaling a bearing and distance from an easily located physical feature on the map or photo to the plot location and measuring this distance on the ground. The starting point should be permanently marked with paint or a metal tag, witness trees established if necessary, and the point should be documented on the back of the field sheet.

If a better access point is discovered in establishing the plot, such as a new road, trail, or firebreak, the original bearing and distance should be used for the initial establishment, but a secondary starting point may be established and documented.

If the route to the plot is marked with paint blazes, the blazes should stop at least 100 feet (30 m) from the plot to avoid any bias in timber cutting operations about the point. The plot center should be permanently marked with a metal pipe or pin. Two or three witness trees should be established to permanently mark the plot location. These trees should be at least 4 inches (10 cm) d.b.h. and likely to be present for 10 years or more. The trees should be marked with metal tags at the ground level facing plot center. Species, d.b.h., the distance and bearing from the metal tag to plot center should be recorded on the field sheet.

While some older inventories may incorporate fixed-radius plots, most new inventories use variable-radius plots for greater efficiency. A prism or other angle gauge may be used to determine trees that are obviously in or out of the plot. Trees for which there is any doubt (borderline trees) must be measured and compared with a table of limiting distances (See figure 81) to determine if they are in or out. It cannot be emphasized too strongly how important this is, as a single tree may represent many thousands of trees in the sample.

Each tree in the plot should be numbered consecutively clockwise from north, and tagged with a metal tag at ground line and/or d.b.h. facing point center. When remeasurement of old photos points is done, remove all old, metal, tree tags and renumber the trees again with a complete new numbering system. This practice will help keep future records more manageable.

If the plot occurs on a slope, the plot must be corrected to horizontal. If the slope is gentle, the easiest way to do this is to use the table of limiting distance (figure 81), holding the tape horizontal in measuring from the center pin to the side of the tree at d.b.h. In this case no correction factor need be recorded. On steeper slopes, the limiting distance should be measured holding the tape parallel to the slope. The steepest slope perpendicular to the contour through plot center should be measured in percent and the appropriate slope correction factor looked up in figure 82 (page 130) and recorded in the XTRA column (see figure 3, page 15).

LAYOUT AND ESTABLISHMENT OF SAMPLE POINTS FOR TIMBER CRUISES

The procedures for the layout of a timber sale are about the same as previously discussed for CFI. The main differences are 1) temporary rather than permanent plots or points and 2) selection of subsample.

As much care and consideration needs to be given to the sample design as before. Procedures used to establish the plot or point location should minimize the bias in the data collected. Usually, because timber cruising is on smaller tracts of land, sampling units are established along a compass line rather than individually located from photographs. Trees within a plot, whether fixed boundaries or variable radius, are usually not specifically identified; however, plot or point centers are frequently marked for short term future reference.

The selection of sample trees to be dendrometered for CFI purposes is usually made after plots or points have been installed. During this selection process, an adequate subsample is drawn from each stratum to produce the necessary summary tables and to ensure a sufficient number of sample trees for future remeasurement. Usually, timber sales are more homogeneous, thus fewer strata need to be sampled, and fewer trees are measured because the final figures are needed once only. Selection of the sample trees for dendrometry is generally done at the same time the plot or point is installed.

Random numbers for selecting the sample trees are generated on the basis of reconnaissance or other prior knowledge of the area and taken to the field for use as the project progresses.

SELECTION OF 3-P SAMPLE TREES

Trees for 3-P sampling and dendrometry are selected by comparing the prediction (volume or height) for that tree with a computer-generated list of random numbers. Trees with a prediction equal to or greater than its corresponding random number are selected for measurement.

To generate an appropriate list of random numbers, the number of sample trees required, the total number of trees in the sample, and the sum of all the predicted volumes or heights for these trees must be known or estimated (figure 1). The largest random number to be generated is found by dividing the sum of the predictions by the number of samples required. For instance, if the sum of the heights on a variable plot sample was 4,125 and the number of 3-P sample trees desired was 75, the largest random number, called "KZ", would be 55.

The largest prediction in the sample is usually known or can be estimated with some margin for safety. Since no trees are likely to be encountered which are larger than this, then random numbers larger than this, even if generated, would never be used. Therefore, any numbers larger than the largest possible prediction, called "K", can be replaced by nulls, signified by 0 or –99999's in the random number list (figure 2). Any trees paired with such nulls are sure-to-be-rejected as samples. If trees are encountered which *do* have a prediction larger than K, these trees must all be measured and treated as sure-to-be-measured trees.

Random numbers are generated and printed by program RN3P in blocks of 500. Enough random numbers should be generated to pair with each tree. Instructions on the use of the RN3P computer program are contained in the program. However, random numbers for 3-P sampling can be produced with any random number generator if the values for K and KZ and the number of random numbers needed are supplied.

RANDOM NUMBER REQUEST FORM
(RN3P)

Control Card 1

Inventory or Stratum Name:

Test Project (columns 5–72)

ID: T E S T (column 73)

Control Card 2

1. Starting number for random number generator (any number 1 through 999999999) (L) — 7 3 1 5 4 6 5 1 2 (columns 2–10)

2. Total number of trees tallied on first stage plots or prism points for this stratum, in multiples of 500 (LIM) — _ _ _ _ 5 0 0 (column 20)

3. Volume or height of largest tree to be sampled (trees with volumes or heights larger than this will be 100 percent sampled) (K) — _ _ _ 2 5 (column 30)

4. Sum of predicted volumes or heights for this stratum: 4125

5. Number of trees to sample in this stratum: 75

6. Divided line 4 by line 5, round to nearest whole number, and enter here (KZ) — _ _ _ 5 5 (column 40)

The number of trees to be sampled can be estimated by using the following formula:

$$n = \frac{t^2 CV^2}{E^2}$$

where:

n = number of trees to sample

t = student, statistic at a given level of probability (approximately 1 for 67 percent level of probabilty and 2 for 95 percent level of probability)

CV = anticipated coefficient of variation of the 3-P subsample

E = desired sampling error as a percent of the mean

Figure 1. – An appropriate list of random numbers can be generated when this form is completed

```
TEST PROJECT                                                    PAGE     1
L=    632587410, LIM=     500, K=      25, KZ=      55
```

0	0	0	0	0	0	0	0	0	0
0	9	0	0	0	0	0	5	0	0
0	0	0	11	0	3	0	0	12	17
23	0	0	18	6	0	6	0	7	0
0	16	4	0	25	0	0	0	0	0
0	0	0	17	0	0	0	0	23	0
0	0	0	5	0	19	23	18	0	2
0	8	0	0	8	7	0	21	4	0
3	4	20	0	0	23	0	16	25	7
0	0	0	0	15	25	0	19	3	0
0	0	0	6	0	0	0	1	0	15
0	19	8	0	23	0	3	0	6	14
0	0	0	4	0	19	0	0	12	0
6	0	0	22	0	3	15	3	14	4
17	19	23	0	0	0	0	20	0	0
21	15	10	13	0	12	15	0	0	24
2	14	0	0	14	0	25	0	2	0
0	0	0	0	7	0	0	0	0	5
14	0	6	12	0	4	13	0	0	17
2	2	19	0	0	0	16	17	2	8
11	6	0	0	12	22	14	22	13	0
0	0	0	23	25	11	23	16	8	0
4	1	0	0	1	0	7	0	0	7
19	5	3	18	24	0	17	15	0	20
0	0	5	23	24	0	0	13	14	10
0	14	0	0	5	8	0	0	0	0
1	12	0	0	3	0	0	1	12	16
0	0	0	24	17	20	0	0	0	0
23	0	0	9	14	23	4	0	6	0
5	0	0	0	0	2	0	18	0	8
0	15	15	19	0	0	21	18	0	19
22	4	0	0	16	9	0	3	18	5
10	0	0	10	0	6	0	13	1	2
0	0	0	0	0	12	0	0	0	0
0	0	0	0	11	0	14	0	9	0
24	0	4	0	10	13	22	17	2	0
0	0	0	0	0	12	0	0	17	12
21	0	0	24	0	0	0	0	10	24
4	10	15	0	0	0	0	0	12	1
0	13	11	0	0	0	0	0	0	21
14	0	0	0	2	0	0	0	0	8
19	2	1	0	0	3	24	0	5	0
0	0	0	25	12	0	0	0	0	0
0	0	7	11	15	0	0	25	0	14
12	0	24	11	0	0	0	24	0	0
13	6	3	0	17	22	0	0	0	0
0	0	22	0	0	14	6	0	0	0
0	18	0	0	7	0	0	19	1	0
0	0	24	5	0	24	8	0	7	4
17	12	0	0	22	0	19	14	0	14

2892
230

Figure 2.–Random number using RN3P with "0" shown as nulls rather than -99999.

The RN3P computer program may be modified to write the random numbers produced onto tape or disk for computer selection of sample trees. You may select 3-P sample trees in the field by taking the random integer list to each plot as it is established and comparing the prediction for each tree with the list as the tree is measured. Those trees selected can be dendrometered immediately.

There are several advantages to establishing the points first and returning later for dendrometry. First, this concentrates the use of the dendrometer and the person trained to run it into a much shorter period of time. Usually, only from one-fourth to one-half of the plots need to be revisited with the dendrometer. Second, if the plots are established before picking the 3-P sample trees, the exact population parameters are known, which makes sampling more efficient. Computer selection of the sample trees by list sampling techniques can be used to ensure the right number and best distribution of sample trees. Also, the population can be screened for very large trees, minor, but valuable species, or other situations that might require 100-percent sampling or at least a more intense sample. The cost of revisiting the points must be weighed against these advantages in deciding whether or not to conduct an inventory in two stages.

The STX tally sheets are designed to facilitate field entries, editing, and punching of data that relate to the tree as a whole (Tree data sheet, figure 3), and data that is card-punched as shown on figure 4. Stem measurements are made along the bole on as many as four measurements per card and four cards per tree, for the diameter and length measurements (dendrometry sheet, figure 5). However, the program is capable of processing the data from a total of nine cards per tree.

In some special cruise situations such as simple 3-P, where predictions are made for all trees in the population, data are recorded for only the 3-P selected sample trees and the predictions may be recorded and totalled on another form.

HAND CALCULATION OF FIELD DATA

Because computers are capable of rapid repetitive computations where sorting and summarizing of the information are performed in micro-seconds, it is usually to our advantage to use the computer. However, there will be times when checking frequency factors or complete hand calculations for final volumes may be desired and the mathematical procedure must be known.

The basic formula for using the simple 3-P sampling theory to calculate frequency is:

$$\text{FREQ} = \frac{\sum_{i=1}^{H} \text{KPI}}{n * \text{KPI}}$$

Where:

$\sum_{i=1}^{H} \text{KPI}$ = Sum of predictions for all trees within a stratum

KPI = Prediction of volume or value (height for point sample) of 3-P selected tree

n = Number of 3-P selected samples within stratum

H = n + NR

NR = 3-P-rejected trees

The frequency is multiplied by the sample tree volume, where this volume may be determined with dendrometry using one of the 10 methods to be discussed later, or from a volume table. The formula then becomes:

$$\text{VOLUME} = \frac{\sum_{i=1}^{H} \text{KPI}}{n * \text{KPI}} * \text{YI}$$

(YI = actual volume of 3-P selected sample tree based on dendrometry or volume tables.)

The volume calculated for each of the sample trees is totalled for the grand total.
Where trees are subsampled with 3-P from point-selected trees, the formula becomes:

$$\text{Volume} = \frac{BAF}{.005454154D^2} * \frac{TA}{NP} * \frac{\sum KPI}{n * KPI} * YI$$

Where:

BAF = Basal Area Factor

$.005454154D^2 = \pi r^2/144$ = square feet of basal area or ($.0000785398D^2 = \pi r^2/10{,}000$ = square meters of basal area) for tree of d.b.h. D inches (cm).

NP = Number of point samples within stratum.

TA = Total acres in stratum (or hectares).

The flexibilty of cruise or inventory design is quite limited when using the above formulas, but much information can be determined by these methods.

When more complex cruise designs are used, the frequency calculations should closely follow the procedure used in the computer program. This practice considers all the various options that are provided to the user. Usually, the following formulas are used for checking frequencies following a computer run and not for total volume calculations.

The frequency of a preselected sample tree (sure-to-measure trees with "=" in column 11) is calculated without regard to KPI, if any was input, and is always:

$$FREQ = QI*CC6*\frac{XTRA}{XTRB*PBI}$$

The frequency of a 3-P sample tree (with "*" in column 11) when LS1 = 1 is always:

$$FREQ = QI*CC6*\frac{XTRA}{XTRB*PBI} * \left[\sum^{NS} \frac{XTRA*KPI}{XTRB} + \sum^{NR} \frac{XTRA*KPI}{XTRB}\right] \Big/ \left[KPI * \sum^{NS} \frac{XTRA}{XTRB}\right]$$

The frequency of a 3-P sample tree (with "*" in column 11) when LS1 = 2 is always:

$$FREQ = QI*CC6*\frac{XTRA}{XTRB*PBI} * \left[\frac{CC8}{CC6} - \sum^{NN} \frac{XTRA*KPI}{XTRB}\right] \Big/ \left[KPI * \sum^{NS} \frac{XTRA}{XTRB}\right]$$

Where:

QI = IQ/100 (IQ/1000 for metric)
CC6 = Multiplier (See control card 6)
XTRA = Multiplier (See tree card)
XTRB = Divisor (See tree card)
PBI = TREE basal area in square feet or meters
CC8 = See control card 8
NN = Number of sure-to-measure trees
NS = Number of 3P selected trees
NR = Number of rejected trees

FOREST INVENTORY
3P and STXMOD
Tree Data

Point No. 1
Date 8-1-79
Crew [illegible]
Unit Name TEST

TREE NO (1–4)	KPI HT or VOL (6–9)	STR (10)	* = (11)	CLASS (12–15)	DBH (17–21)	MET (22)	XTR A (MULTIPLIER) (49–56)	XTR B (DIVISOR) (64–71)	TM (72)	POINT NO (77–80)	REMARK
1	65	1		BS12	12.6					1	
2	72	1		BS12	13.1					1	
3	41	1		BS12	16.4					1	
4	85	1	*	BS12	17.2					1	
5	65	1		BS15	12.1					1	
6	14	1	=	BS15	2.4				*	1	
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						
					.						

General Information

SEC ____ T ____ R ____ QUAD ____ PHOTONO ____ COMP ____ SUBCOMP ____ STAND ____ OTHER ____

STARTING POINT DESCRIPTION ____________________

DISTANCE TO POINT ____________ BEARING ____________

WITNESS TREES

SPECIES	DBH	DISTANCE	BEARING

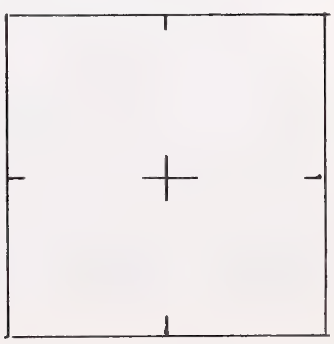


Figure 3.–Tree data sheet.

SA-3200-1 (7/81)

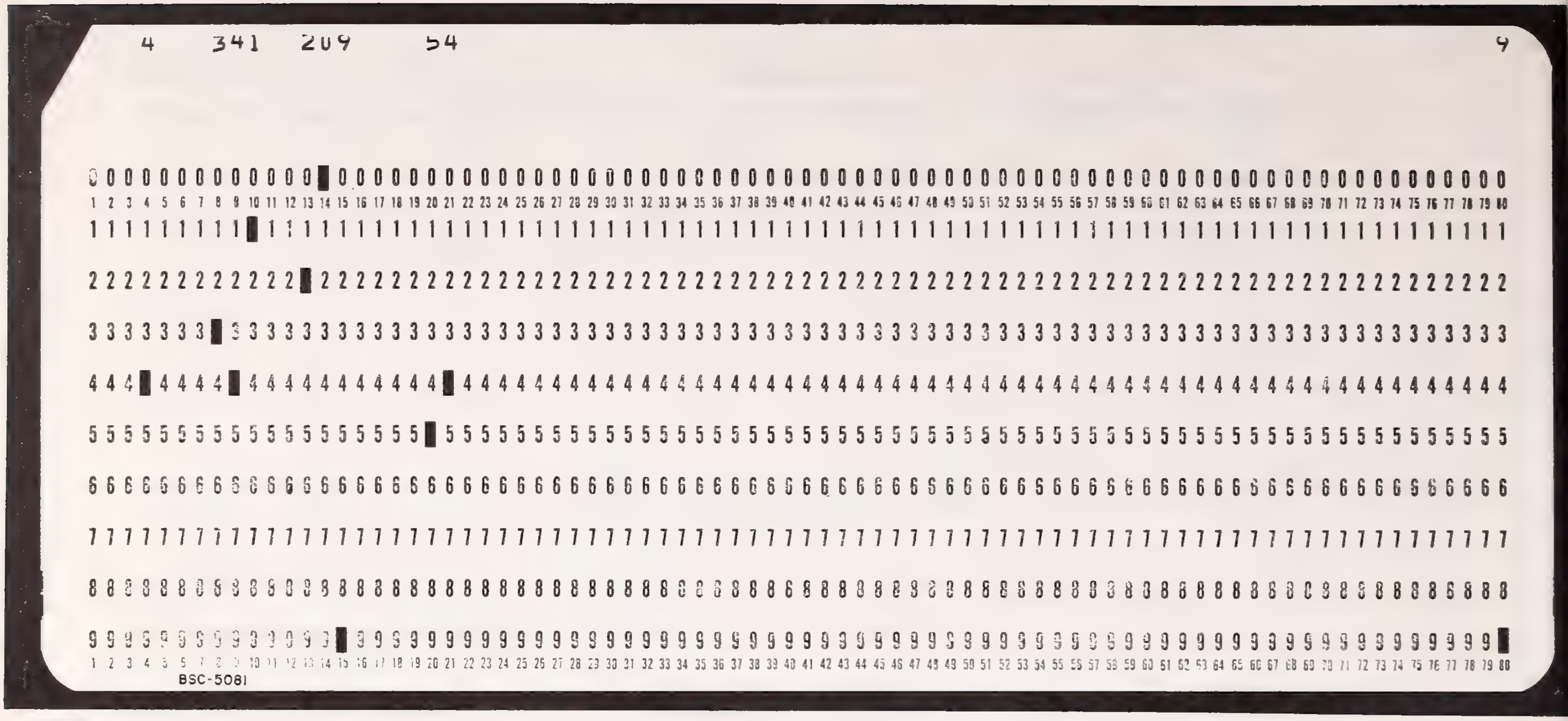


Figure 4.–Tree data for predicted tree only.

TREE DATA

The following data must be recorded for all trees included on the sample plot or point when using the STXMOD program for forest inventory purposes or large cruises where point or plot first-stage sampling are used (figure 3).

To assure successful processing of data, entries on tally sheets must follow explicitly the recording directions below:

Card column	**Entry on Tally Sheet**	**Variable name**	**Statement format**
1-4	Data processing is simplified if a unique tree number can be recorded for each tree. The numbers need not be consecutive and may follow any scheme desired; however a suggested method is to record the point or plot number in columns 77 to 80 and number the trees of each point or plot consecutively starting from "1." By combining the point or plot number with the tree number, a unique identification is given each tree in the sample.	KREENO	I4
5	Column 5 is blank on the tree tally sheet (figure 3), but is used for the card number within the tree on the dendrometer tally sheet (figure 5).	JQ	I1
6-9	**Predicted Volume or Height**		
	A. All trees on fixed-radius plots, or 100 percent tally with 3-P sample, enter volume – either guessed or from volume table (cubic, board feet, cubic meter).	KPI	I4
	B. Trees on variable-radius plot: enter height (guessed or measured). Use total height or height to a merchantable top, in feet (meters) or in logs, bolts, or any other product unit that is directly convertible to feet (meters). Height or volume should be entered to the *nearest whole number.*		

Card column	Entry on Dendrometer Cards	Variable name	Statement format
	Trees for which no volume is needed (culls, submerchantable trees, etc.), but for which basal area and number of trees are desired should be recorded as sure-to-be-measured trees ("=" in sampling class, column 11) with an asterisk in TERM (column 72). No predicted height or volume is needed for such trees.		
10	**Stratum.** – If the sample is not stratified, this field can be left blank. Otherwise, enter a stratum number from one to nine. Samples may be stratified by geography, species, d.b.h. group, or any other scheme.	LST	I1
11	**Sampling Class.** – (Blank, *, =) – Enter "=" for sure-to-be-measured trees. Enter "*" for trees selected for dendrometry by 3-P sampling. Leave blank for all other trees.	CERT	A1
12-15	**Class.** – Use this field to record any desired tree classifications, such as species, d.b.h. group, etc. This field will accept both alphabetic and numeric codes.	BETATH	A4
16	**Blank.** – This field is not used.		1X
17-21	**D.B.H.** – Enter d.b.h. to nearest tenth inch. A decimal point is implicit, but entering a decimal point will override (Format, F5.1). S.I. Units=centimeters and tenths).	DBH	F5.1
22	Use this column to identify units of measurement (U.S. or metric) for input; it must agree with Column 65 on control card 2 ("blank" for U.S. and "+" for metric). When metric measurements are taken, a "+" must be entered for all trees on the point or plot. (If used, enter column 22 on both Tree Data and Dendrometry Data forms.)	JIM	A1
23-51	See *Additional Tree Data,* page 21. (This data is entered for sample tree only.)		
52-56	**XTRA Correction.** – Leave blank when all trees or trees on fixed-radius plots are sampled. For trees on variable-radius plots, enter the product of the following correction factors: 1. Slope correction secant of slope perpendicular to the contour (see table 1). Figure 81. 2. Partial sweep correction if half or quarter sweeps are taken to correct for boundary-line slopover. The correction factor is the reciprocal of the sweep. For example, the correction factor for a half-sweep would be 2.	XTRA	F15.0

Card column	Entry on Tally Sheet	Variable name	Statement format
	3. If the basal area factor is changed during the inventory, the factor being used or a multiplier of that factor must be entered here for proper weighting of the point as it relates to the total volume. 4. If the sampling intensity varies within a stratum, the area represented by this particular point, or a multiplier, must be entered. XTRA may vary by tree, cluster, or stratum and may be the product of the above factors acting together.		
57-71	**XTRB.** – Leave blank for most sampling schemes; it is a divisor and may vary by the tree or stratum, and may be the product of several divisors acting together. However, for each relative probability, a corresponding factor must be present in CC6 to convert relative probabilities to absolute.	XTRB	F15.0
72	**Term.** – Normally blank but should contain an asterisk (*) when only the basal area and number of trees are needed for cull or other unmerchantable trees, and/or frequency factors are needed for future use.	TERM	A1
73-76	**Blank.** – For all trees not selected for measurement.		
77-80	**Point Number.** – Plot or point number or other sampling unit identification; maximum number size is 1,500. Blank for simple 3-P cruise (100 percent marking).	PLOTNO	I4
	Miscellaneous. – This column is not key-punched and may be used for any purpose. Thoroughly field check your data for any errors or omissions. If you are working with a partner, have him or her check your work. It's a lot easier to locate errors while on the plot than to have to return to pick up missing or incorrect data.		

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
2	95	1	=	TRAN	15.6	4	2			.8	.		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	14

Dendrometry Data

TREE NO. (1) J (5) T GRADS F GRADS SINELV GR LEAN deg.

Cols. 1-4, 73-80 are in every card.

Tree No.	J	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	
2	1	12		16	.75	20	-1530	25		
		27	-999	31	17.5	35	3.5	40		
		42		46	15.6	50	4.0	55	ST	72
		57		61	15.5	65	-0230	70	ST	
	2	12		16	13.2	20	1500	25	ST	
		27		31	11.4	35	2245	40	ST	
		42		46	10.5	50	2330	55	ST	72
		57		61		65		70		+
	3	12		16	.82	20	-2030	25		
		27	16	31	9.5	35	2815	40	PW	
		42	15	46	8.5	50	3100	55	PW	72
		57		61		65		70		+
	4	12		16	.82	20	-2030	25		
		27	19	31	9.6	35	2830	40	PW	
		42	19	46	7.2	50	3145	55	PW	72
		57		61		65		70		*

GROWTH (73–76)	CFI POINT NO. (77–80)
.7	14

Sketch tree below

For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 CC

Figure 5.–Dendrometry sheet showing entries for four cards; up to nine cards per tree can be prepared.

DENDROMETRY

Trees for dendrometry are selected by comparing random numbers generated by computer program RN3P; when the predicted height or volume is equal to or greater than the random number (nulls excepted), the tree is selected. Selected trees should have an asterisk (*) recorded in card column 11 (figure 6).

Sure-to-be-measured trees (those with predictions larger than "K" or in a stratum calling for 100-percent measurement) for which volume information is desired must also be dendrometered. These trees must have an equal sign (=) recorded in column 11 (figure 6).

Tree Card

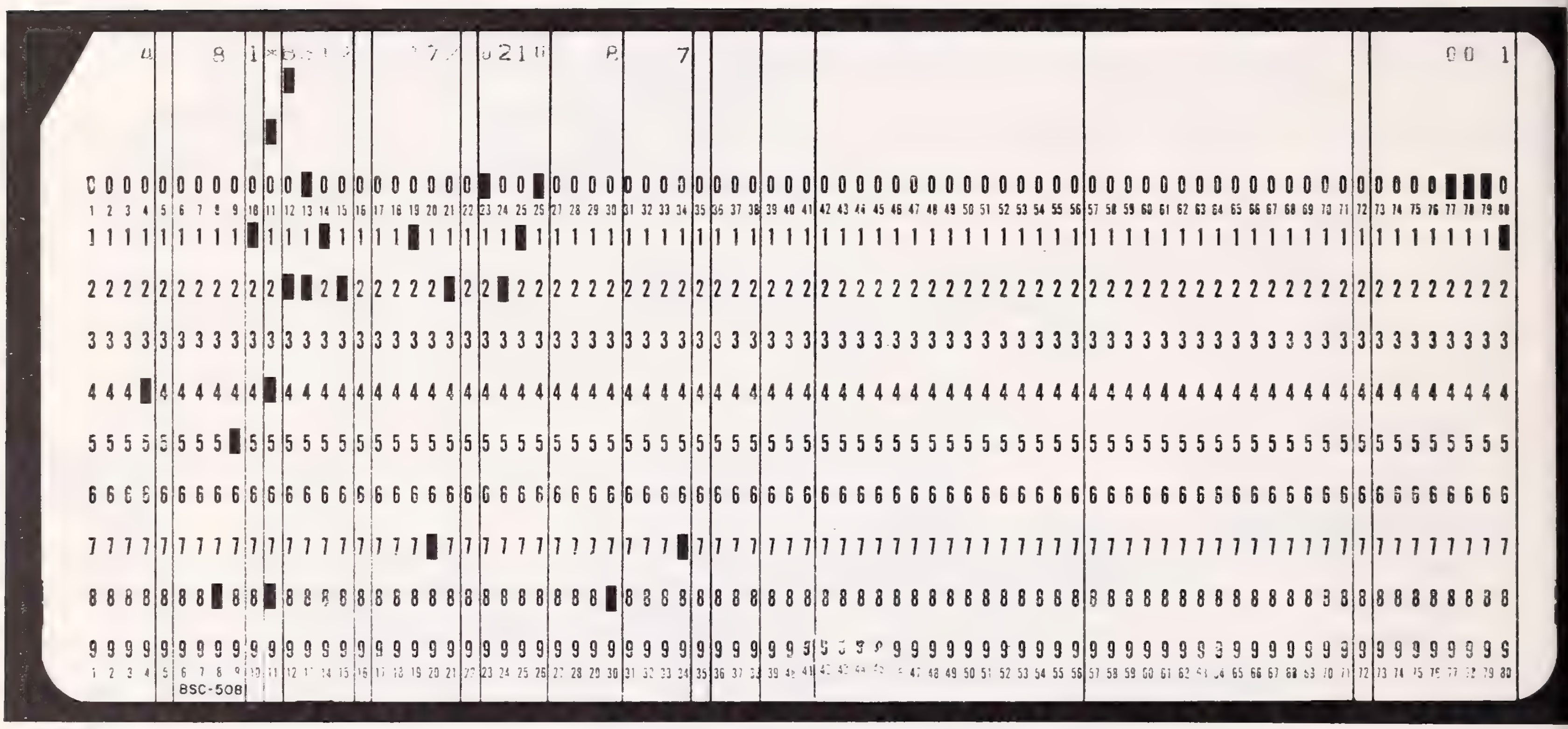


Figure 6.–Tree card for 3-P selected trees. Sure-to-be-measured trees are recorded with an "=" in column 11.

Additional Tree Data

The following *additional* tree data must be recorded for all measured trees, whether sure-to-be-mesured or 3-P selected. **Options: Fields 23-26.**

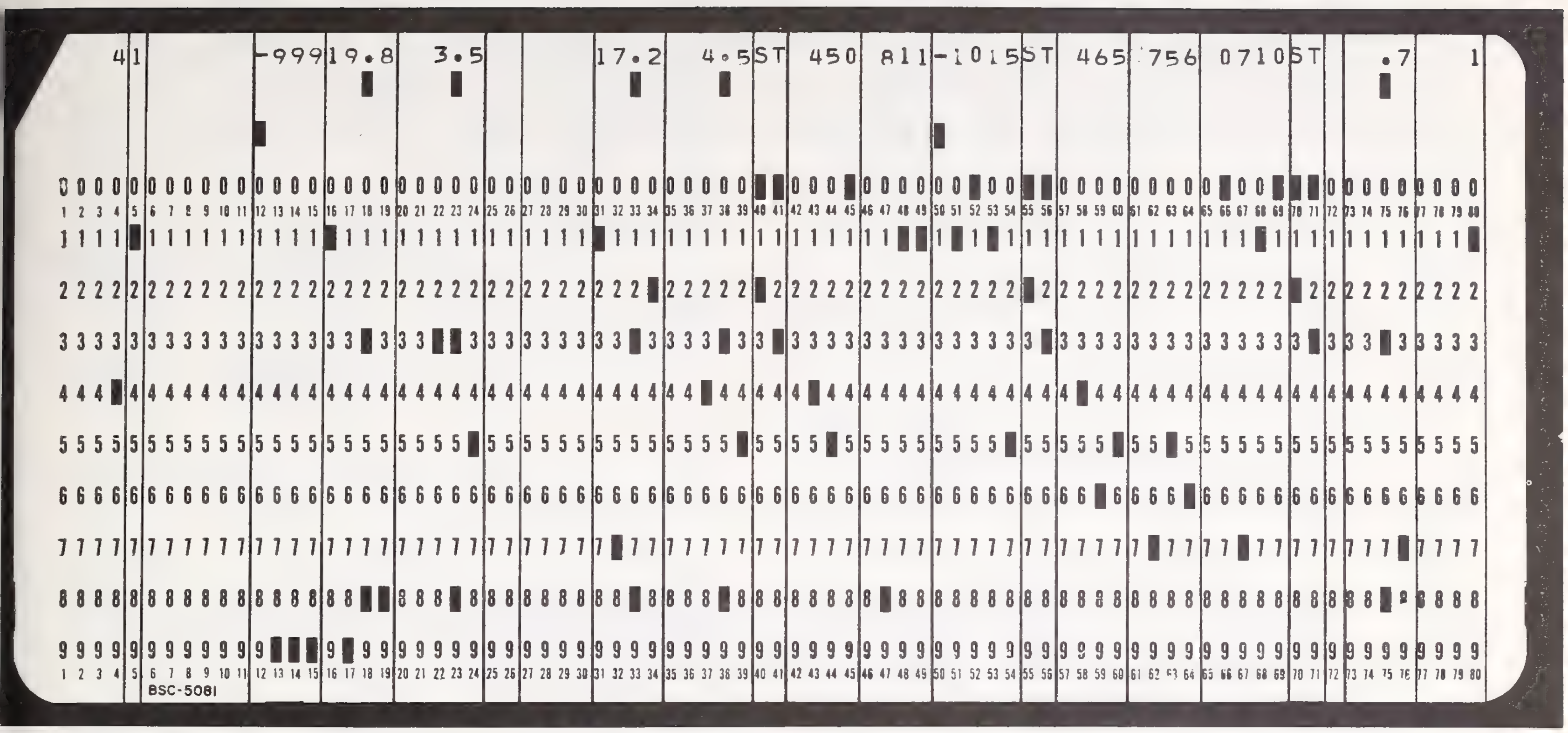
Field	Entry on Tally Sheet	Variable name	Statement format
23	**Type of Measurement.** – Field 23 codes the method used for measurement. 0 Barr and Stroud FP-12 (earlier model) dendrometer 1 Barr and Stroud FP-15 dendrometer 2 Direct reading calipers, tape, felled tree where each log length and diameter is entered directly 3 Modified Zeiss Teletop dendrometer 4. Transit dendrometer 5 American Scale Relaskop 6 Direct reading caliper, 100-foot base (i.e., Wheeler, Penta-prism, McClure mirror caliper, Transit dendrometer, and Tele-Relaskop) 7 Direct reading caliper, 66-foot base 8 Todis dendrometer 9 Tele-Relaskop Field procedures for use of each method are discussed in the *Instruments and Recording Tree Measurements* portion.	METH	I1
24	**Bark.** – Usually enter "1" for hardwoods, "2" for softwoods and "3" for trees where the relative bark thickness tends to increase up the tree. However, to establish the proper option for any species (or tree), measurements of bark and diameter outside bark (d.o.b.) should be made at stump height, at breast height, and as high as can be reached from the ground for as many trees as needed to establish a trend; this is usually about 10 sample trees of a given species. The d.i.b./d.o.b. should be computed and averaged at each level. Bark option is "0" or "1" if d.i.b./d.o.b. for three levels is constant, "2" if it increases with height, and "3" if it decreases with height. See figures 66,67,68,69 for examples of the 3 options.	MBK	I1

Field	Entry on Tally Sheet	Variable name	Statement format
	Procedures used by the computer are: **Option 0 or 1.** – The d.i.b./d.o.b. at any point on the stem assumed equal to (d.b.h.i.b./d.b.h.o.b.) (abnormal taper) (figure 66). **Option 2.** – The d.i.b./d.o.b. is projected hyperbolically. The d.i.b./d.o.b. is made to increase above breast height and decrease below breast height; i.e., relative bark thickness is programmed to decrease up the stem (most softwoods) (figure 66). **Option 3.** – The d.i.b./d.o.b. is projected hyperbolically. The d.i.b./d.o.b. is made to decrease above breast height and increase below breast height; i.e., the relative bark thickness is programmed to increase up the stem (figure 66).		
25	**Unseen material.** – If you can obtain measurements at or above the merchantable top, leave this field blank. If you have four or more uninterrupted measurements (an interruption is caused by a fork or a shift in instrument position) the computer is able to project to a specified merchantable top based on its analysis of taper and form. Put "1" in this column to trigger this projection (*However, enter total height, estimated unseen merchantable length, and rate of taper on the dendrometry data field sheet (figure 5) in "remarks" as a check on this projection.)* If you do not have enough mesurements for computer projection, enter code 2. Unseen merchantable length and rate of taper should be entered on the tree data sheet in the columns headed UML and UDT, and also as a remark at the bottom of the dendrometer sheet along with the total height.	MUL	I1
26	**Interpolation.** – The computer program performs interpolation of measurements for specified top and intermediate diameters, either inside (d.i.b.) or outside bark (d.o.b.). Interpolation is triggered by coding column 26 of the tree data card as follows: 0 or Blank = no interpolation (tree processed exactly as measured). 1 = Interpolate to fixed top d.o.b. (the portion of the tree smaller than this will be discarded). 2 = Interpolate to fixed intermediate d.o.b. 3 = Interpolate both fixed top and intermediate d.o.b. 4 = Interpolate to fixed top d.i.b. 5 = Interpolate to fixed intermediate d.i.b. 6 = Interpolate both fixed top and intermediate d.i.b. This procedure allows the delineation of product classes for which the only limitation is product size. For example, if the limiting product size for pulpwood is 4 inches (10 cm) and for	JAM	I1

Field	Entry on Tally Sheet	Variable name	Statement format
	sawtimber is 7 inches (18 cm), these points on the tree stem can be found by interpolation. Where limitations of product merchantability are due to roughness, limbiness, straightness, or other factors, the limits of a product in the tree should be defined by measurements at the points where products change, rather than by interpolation. Thus, code a "0" for no interpolation.		
27-34	**Bark.** – Enter one or two bark thicknesses in *inches* (cm) and *tenths*. Data may be entered without a decimal point if right justified. When measurements are taken inside bark, enter –009 (no deduction will be made). If no entry of bark thickness is recorded, the program assumes that d.b.h.i.b./d.b.h.o.b. is .90 and the mode of correction is guided by the option coded in column 24.	BKA and BKB	2F4.1
35	**Blank.** – This column not used.		1X
36-38	**UML.** – For unseen material option code 2 (column 25), enter unseen merchantable length. Lengths 10 feet (10 m) and over must be entered to the nearest whole foot (meter). Lengths under 10 feet (or 10 meter) may be entered to the nearest tenth of a foot (decimeter) by entering a decimal figure.	UMAXL	F3.0
39-41	**UDT.** – For unseen material, option code 2 (column 25), enter the rate of taper of the unseen material in inches per foot (cm/m) of length. For example, unseen material tapering at a rate of ¼ inch per foot (¼ cm/m) would be entered as .25.	UDORT	F3.3
42-56	**XTRA.** – This is a multiplier when IQ=–1 (columns 56 to 64 on Control Card 2) that may vary as needed by tree, cluster, or stratum and may be the product of several factors acting together, such as slope, slopover, basal area or acres (hectares) per point. This is especially useful when remeasuring sample trees from a permanent inventory where frequency factors have already been calculated and when using three or more stage sampling designs.	XTRA	F15.0
57-71	**XTRB.** – A divisor that may vary by the tree, cluster, or stratum and may be the product of several divisors acting together.	XTRB	F15.0
72	This field is normally blank but when an "*" is entered it will produce a tree count and calculate a frequency factor for use in later inventories.	TERM	A1
73-76	Volume deductions in percent or board feet for the product grade code designated on control card 10, columns 24 and 25.	DEDT	F4.0

Field	Entry on Tally Sheet	Variable name	Statement format
	Figures should be either in whole percent or the nearest board foot (not Decimal C). If entries are not in whole percent or feet, the decimal must be included. On control card 10, columns 57 and 58 must be completed if this option is used. The type of defect deduction must remain the same throughout. (S.I. units are cubic meters or percent).		
78-80	**Plot Number.** – The point or plot number is needed for calculating the statistics of the first stage sample of a multi-stage inventory. The same number must be entered on the tree data and dendrometer data cards when used, but may be left blank for all cards when statistics are not desired.	PLOTNO	I4

Dendrometer Card



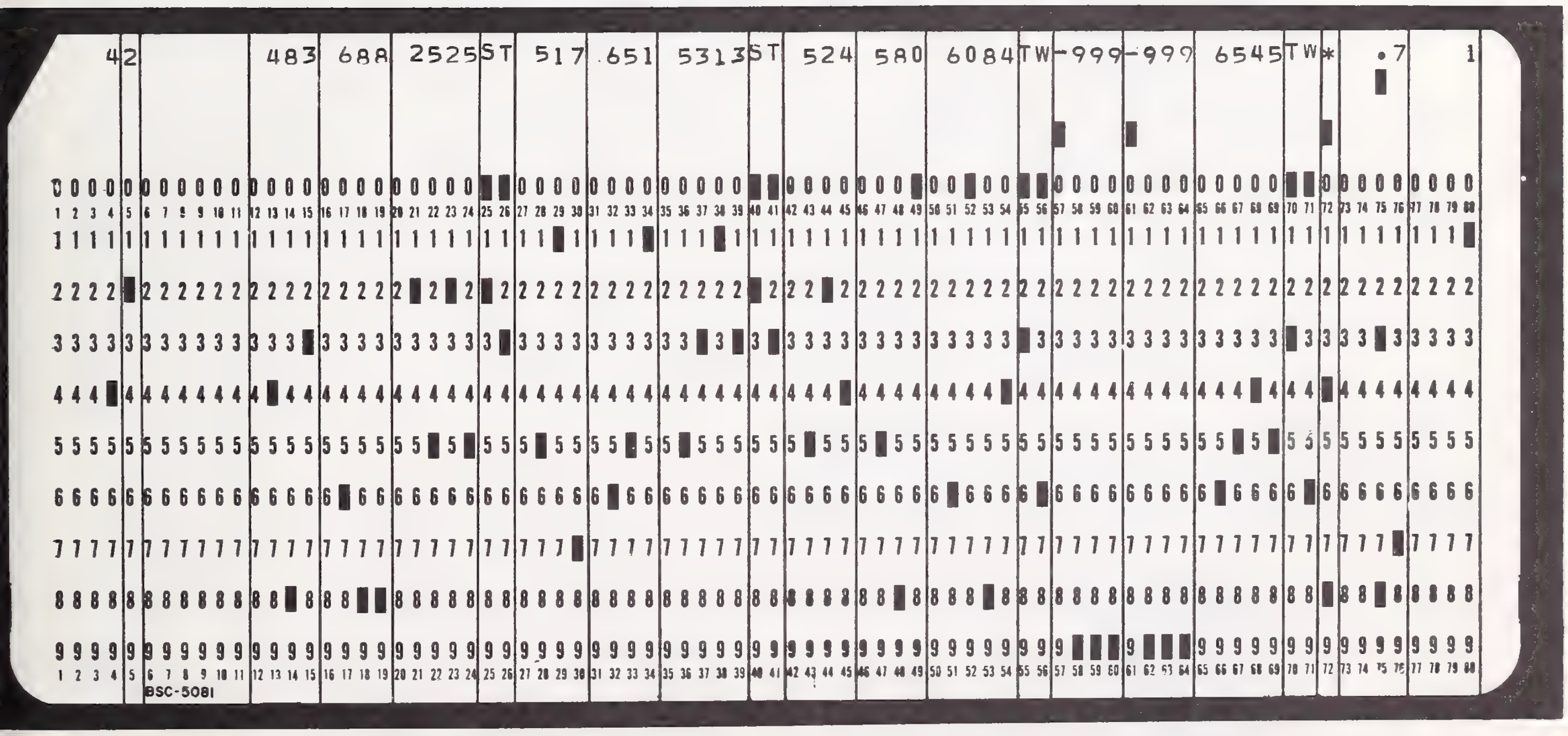


Figure 7.–Two cards are used to record the necessary measurements for this tree. Nine cards can be used if needed.

Dendrometer Card

When a sample or sure-to-be-measured tree is identified (column 11 of the tree data card has an * or =), one or more dendrometer cards must follow. The exception is when only the number of trees is needed, which is indicated by an asterisk (*) in column 72 of the tree data card. Each dendrometer card must have the same tree number in columns 1 to 4 and the same point number in columns 77 to 80 as the tree card that preceded it.

Card column	Entry on Dendrometer Cards	Variable name	Statement format
1-4	Tree number	KREENO	I4
5	Card number within that tree	JQ	I1
6-11	Blank		6X
12-15	**TGRADS.** – A representation of the distance from the tree. Depends on the types of instruments used to measure the tree. (First tree section)	TGRADS	F4.1
16-19	**FGRADS.** – A representation of tree diameter dependent on the instrument used. (First tree section)	FGRADS	F4.1
20-24	**SINELV.** – A representation of height or distance from the last measurement. (First tree section)	SINELV	F5.4
	Each of the above trio of measurements, if needed, is recorded for all measuring points on the sample tree.		
25-26	**GR.** – The grade of the section between this measurement and the previous measurement. This may be any alphanumeric combination desired by the user (examples: Sawtimber=ST, Topwood=TW, Pulpwood=PW, and Plywood Log=PL, etc.).	GAMATH	A2
27-41	Same as columns 12 to 26 (second section)		
42-56	Same as columns 12 to 26 (third section)		
57-71	Same as columns 12 to 26 (fourth section)		
72	1) Blank when additional readings are on the next card. 2) + when dendrometer readings are interrupted by a fork or a change in instrument position. 3) * for the final dendrometer card of that tree.	TERM	A1
73-76	Radial growth in inches and tenths (cm and mm) for the desired number of years recorded with a decimal point. Growth must be recorded on each dendrometer card for the tree (format F4.0).	GROWTH	F4.0

USE OF INSTRUMENTS AND RECORDING OF TREE MEASUREMENTS

The STX tally sheet is designed in two parts to facilitate field entries, editing and punching of data: 1) the *tree data* relate to the tree as a whole, and 2) the *dendrometer data* relate to the stem measurements made along the bole on as many as nine cards per tree.

The following sections discuss the *dendrometry data* for each of the instruments when recording tree measurements.

Barr and Stroud Dendrometer

Two models of the Barr and Stroud dendrometer will be discussed: The FP-12, an earlier model, and the FP-15, a later and the most used model. The only functional difference between them is the procedure of reading and recording the vertical scale. This difference is discussed later under *SINELV*.

Both instruments require specific, related information that is used in the calculations of diameter and height. Most copies of the STX-MOD program have incorporated this information into it. However, if the information is needed, it is as follows (refer to control card 2, columns 17 to 43):

B=(columns 17 to 22) 08.000 (enters as 08000), short-base-range finder dendrometer, optical base in inches (20.320 cm).

Q=(columns 23 to 31) .01964673, enter as 01964673, sine of ½ the maximum deflection caused by counter-rotation of shortbase-range-finder dendrometer prisms away from the neutral position.

U=(columns 32 to 37) –1.1905 (enter as –11905), constant amount of deflection in degrees built into a given short-base-range finder dendrometer and algebraically added to the variable deflection caused by the prisms' counter-rotations.

G=(columns 38 to 43) 1.5658 (enter as 15658), refractive index of the glass used in the counter-rotating prisms.

Models FP-12 and FP-15 (options 0 and 1)

Record in column 23 of *tree data* card (figure 5).

Option "0" applies to the FP-12 Barr and Stroud dendrometer; Option "1" applies to the FP-15 model.

Both models of this instrument incorporate a range-finder; therefore, no baseline is necessary. The instrument may be set up wherever the view of the tree's bole is best, but must be at least 36 feet (11 meters) from the tree.

Trios of measurements are taken at each point on the tree, beginning at the bottom and working upward. There is no set rule for the number of points at which the tree should be measured. At a minimum, however, readings should be taken wherever the form, product, or grade of the tree changes. Because these readings can be taken rapidly, and you have already taken the time and expense to reach the tree, you should take a minimum of six readings, including the stump and the d.b.h., which are usually measured directly. On each reading, make sure that the vertical fiducial mark at the top of the field of vision is approximately coincident with the left side of the tree, and the split image cuts at a right angle through the bole.

Recording

TGRADS. – A reading with the image of the tree in true coincidence, or as the tree normally appears, provides the range to the tree. The left-hand edge of the tree should be aligned as shown in figure 8 (the right-hand edge may be slightly out of line) by rotating the knob at the right end of the instrument. Read TGRADS on the vernier scale at the upper right of the instrument (figure 9). Enter the reading on the field sheet as a four digit number without a decimal point, i.e., 23.1 would be entered as 0231. Unless

Figure 8.–Left-hand alinement for TGRADS.

the tree is leaning toward you or is downhill from you, these readings will normally *increase* as you go up the tree because the range (slope distance) is increased.

FGRADS. – A reading with the image of the tree in false coincidence, or completely offset, corresponds to the diameter of the tree. Rotate the knob at the right of the instrument until the left-hand side of the top image is exactly in line with the right-hand edge of the bottom image (figure 10). FGRADS is then read on the vernier scale (figure 9). Enter the reading on the field sheet as a four digit number without a decimal point, the same as the TGRADS reading. Unless the tree is leaning toward you, is downhill from you, or a section has reverse taper, these readings will normally *decrease* as you go up the tree.

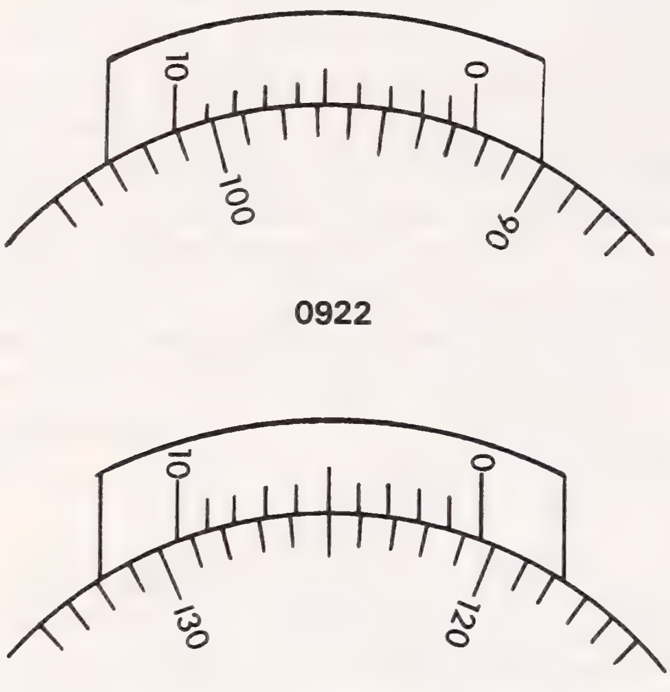


Figure 9.–Examples of grad scale settings.

Figure 10.–Offset alinement for FGRADS.

SINELV. – The coded sine of the elevation above and below horizontal is read by moving the micrometer type adjustment at the left of the instrument until the bubble in the level tube is centered. SINELV is read from the vernier and entered as a five digit number without a decimal point, i.e., when using the FP-15 model, 0.6 271 would be entered as 06271 and 1.2546 would be entered as 12546 (figures 11 and 17). These same measurements on an FP-12 model would be recorded –3729, reading negative sighting from the red scale, and +2546 reading a positive sighting from the black scale (figures 12 and 16). *Be very careful in making these readings because many errors are made here.* The dendrometer units and tenths are read on the fixed part of the vernier scale. Hundredths and thousandths are read on the rotating head, with ten thousandths being estimated. (For the FP-12 model, units are recorded as + or –, reading the black numbers when above horizontal "+", and reading the red numbers when below horizontal "–"). These readings will always *increase* as you go up the tree unless a change in the plane of reference has been signalled by coding TERM with a "+" sign. Figures 13, 14 and 15 show examples of recording procedure for both models of the Barr and Stroud dendrometer, and the computer output.

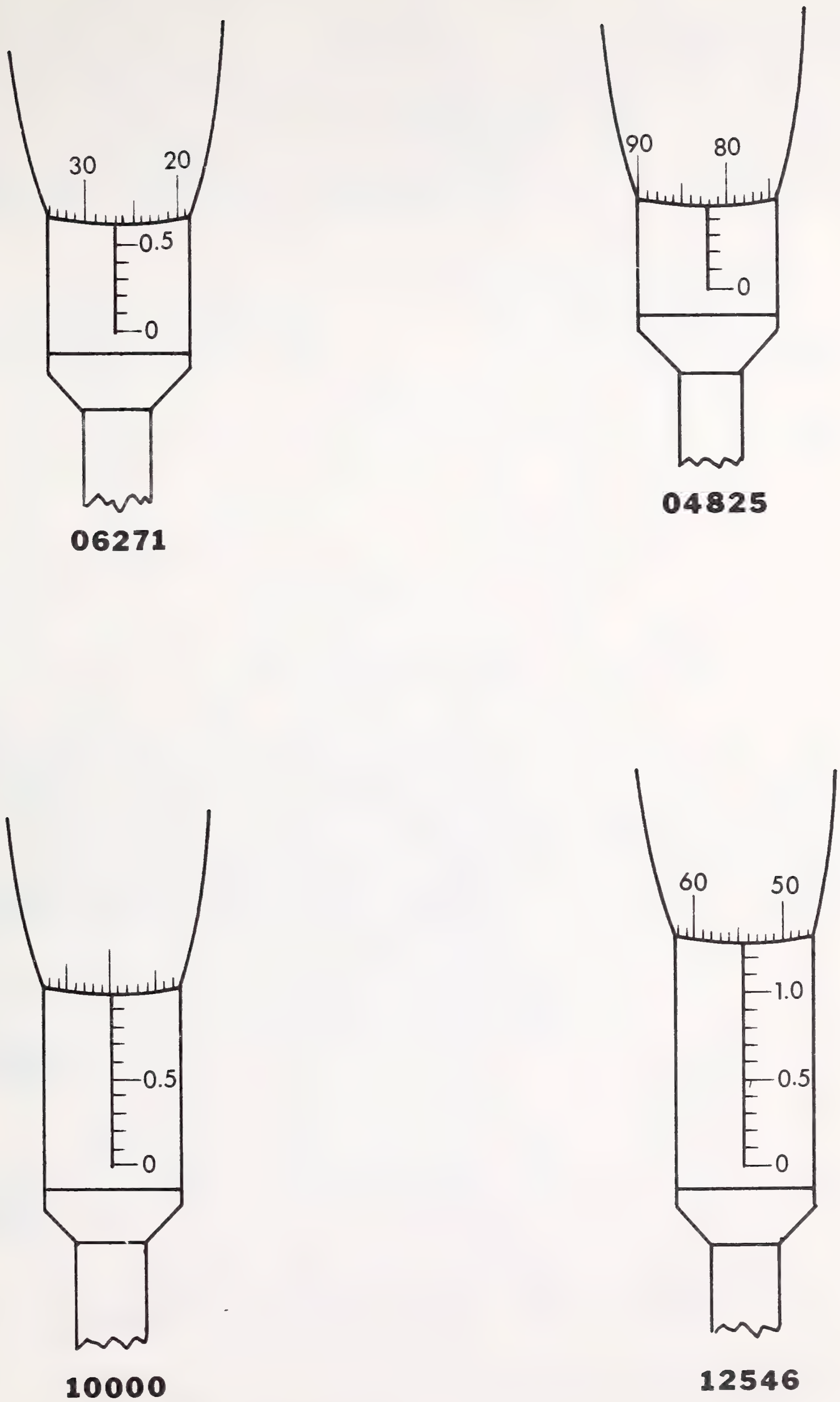


Figure 11.–Examples of inclinometer settings, model FP-15 dendrometer.

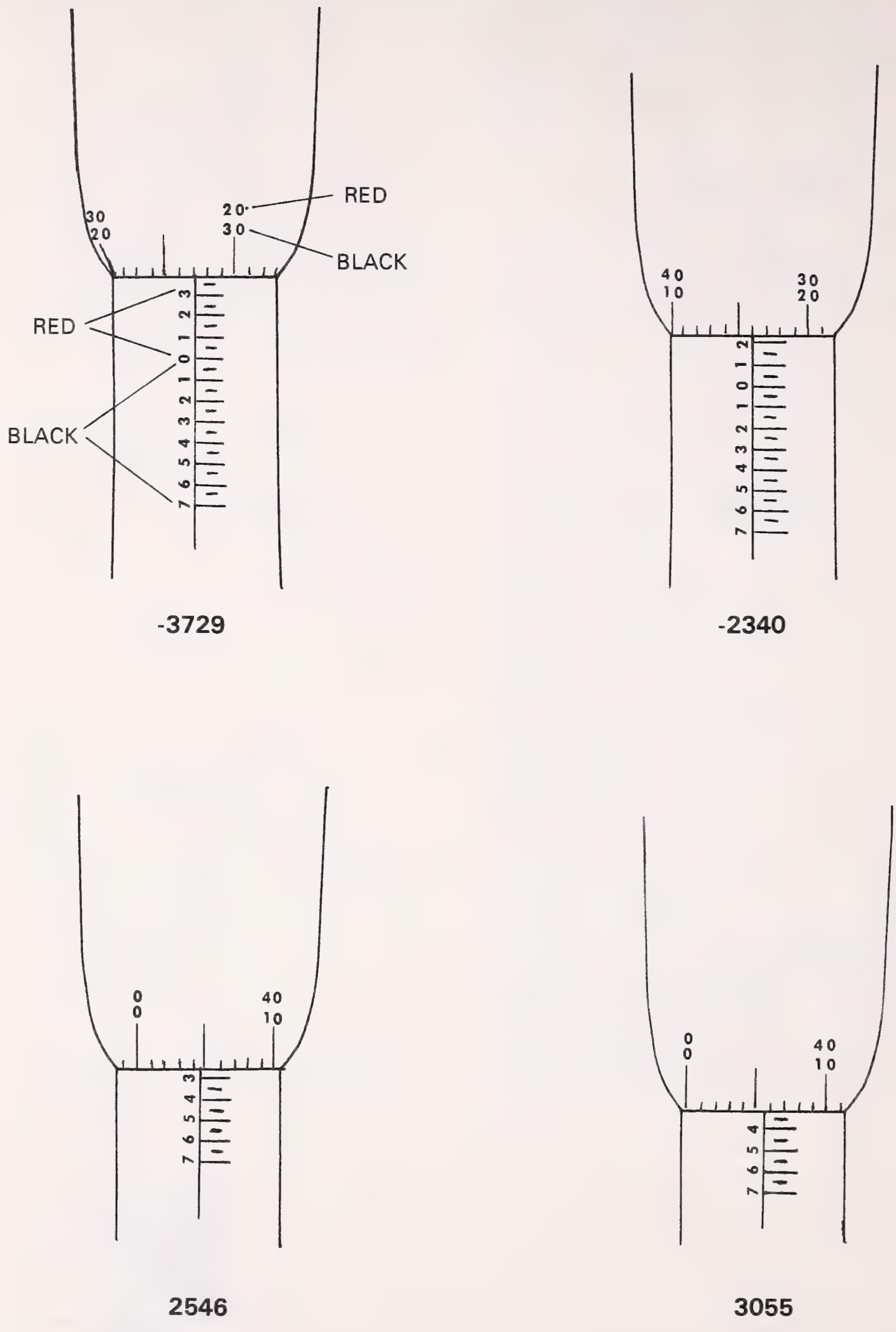


Figure 12.–Examples of inclinometer setting, model FP-12 dendrometer.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
4	85	1	*	8512	17.2	0	2	1	0	.8	.7		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	1

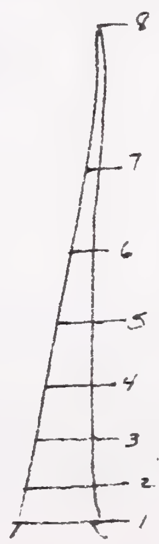
Dendrometry Data

TREE NO. (1–4)	J (5)	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	
4	1	12	-999	16	19.8	20	3,5	25		
		27		31	17.2	35	4.5	40	S	T
		42	450	46	811	50	-1015	55	S	T	72
		57	465	61	756	65	07105	70	S	T	
	2	12	483	16	688	20	2525	25	S	T
		27	517	31	651	35	5313	40	S	T
		42	524	46	580	50	60847	55	T	W	72
		57	-999	61	-999	65	65457	70	T	W	*
	3	12		16		20		25		
		27		31		35		40		
		42		46		50		55			72
		57		61		65		70			
	4	12		16		20		25		
		27		31		35		40		
		42		46		50		55			72
		57		61		65		70			

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)
.7	1

Sketch tree below



LEAN deg.

For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 CC

Figure 13.–Example of Barr and Stroud model FP-12 recording procedure for a measured tree.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S T r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Back A (27–30)	Back B (31–34)	UML (36–38)	UDT (39–41)
7	35	1	*	8515	10.5	1	2		0	.6	.		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
10	1

Dendrometry Data

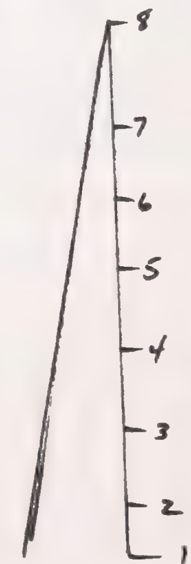
TREE NO. (1–4): 7 J (5): 1

Cols. 1-4, 73-80 are in every card.

Card	T GRADS	F GRADS	SINELV	GR	72
1 (12)	-999	13.5	4.0		
(27)		10.5	4.0	5T	
(42)	396	682	10845	5T	
(57)	387	649	11675	7W	
2 (12)	399	651	72535	7W	
(27)	405	638	73060	7W	
(42)	416	587	73825	7W	
(57)		-999		7W	*
3 (12)					
(27)					
(42)					
(57)					
4 (12)					
(27)					
(42)					
(57)					

GROWTH (73–76)	CFI POINT NO. (77–80)
.8	1

Sketch tree below



LEAN deg.

For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 CC

Figure 14.–Example of Barr and Stroud model FP-15 recording procedure for a measured tree.

```
DENDROMETRY EXAMPLES AND OPTIONS                                   TEST  PAGE   5
CPC 8-04-80                                        2    400.  160     15467 123020
                       DETAILED LOG AND/OR TREE REPORT
==================================================================================
TREE/  VOLUME  / SURFACE / LENGTH /  DIB   / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /   FT.  /  IN.   /CODE/  FT./ TGRADS  FGRADS    SINELV
==================================================================================
              .2       4.0      8.8       .1   TW      .0   -99.9  -99.9      .6545
             2.1      17.3     11.7      3.4   TW   112.5    52.4   58.0      .6084
            14.9      80.7     35.0      7.9   ST   106.8    51.7   65.1      .5313
            11.2      47.7     16.2      9.7   ST    86.3    48.3   68.8      .2525
            13.6      47.1     13.0     12.8   ST    78.6    46.5   75.6      .0710
             5.7      18.0      4.5     14.8   ST    73.3    45.0   81.1     -.1015
             5.4      15.3      3.5     15.7   ST      .0      .0   17.2     4.5000
              .0        .0       .0     17.8           .0   -99.9   19.8     3.5000
----------------------------------------------------------------------------------
   4 SUMS  53.1      230.1     92.7  /  17.2 = D.B.H.    FREQUENCY =        181.188
     PREDICTION =    85  D.B.T. =  1.50  FORK   OPTIONS = 0210 UNSEEN MATERIAL
     CLASS = BS12    VALUE STRATUM =  1    BASAL AREA =  1.61
     PLOT OR POINT NUMBER      1   GROWTH =      .70
**********************************************************************************
              .2       2.2      1.8      3.7   TW      .0      .0  -99.9      .0000
             1.2       9.1      5.6      5.3   TW    64.0    41.6   58.7      .3825
             1.0       6.7      3.5      7.0   TW    61.6    40.5   63.8      .3060
             1.7      10.8      5.6      7.5   TW    60.4    39.9   65.1      .2535
             1.6       9.7      4.7      7.4   TW    58.1    38.7   64.9      .1675
             1.7       9.3      4.0      8.4   ST    59.8    39.6   68.2      .0645
             2.3      10.8      4.0      9.3   ST      .0      .0   10.5     4.0000
              .0        .0       .0     11.3           .0   -99.9   13.5     4.0000
----------------------------------------------------------------------------------
   7 SUMS   9.7       58.7     29.2  /  10.5 = D.B.H.    FREQUENCY =       1180.750
     PREDICTION =    35  D.B.T. =  1.20  FORK   OPTIONS = 1210 UNSEEN MATERIAL *
     CLASS = BS15    VALUE STRATUM =  1    BASAL AREA =   .60
     PLOT OR POINT NUMBER      1   GROWTH =      .80
**********************************************************************************
```

Figure 15.–Dendrometry examples and options.

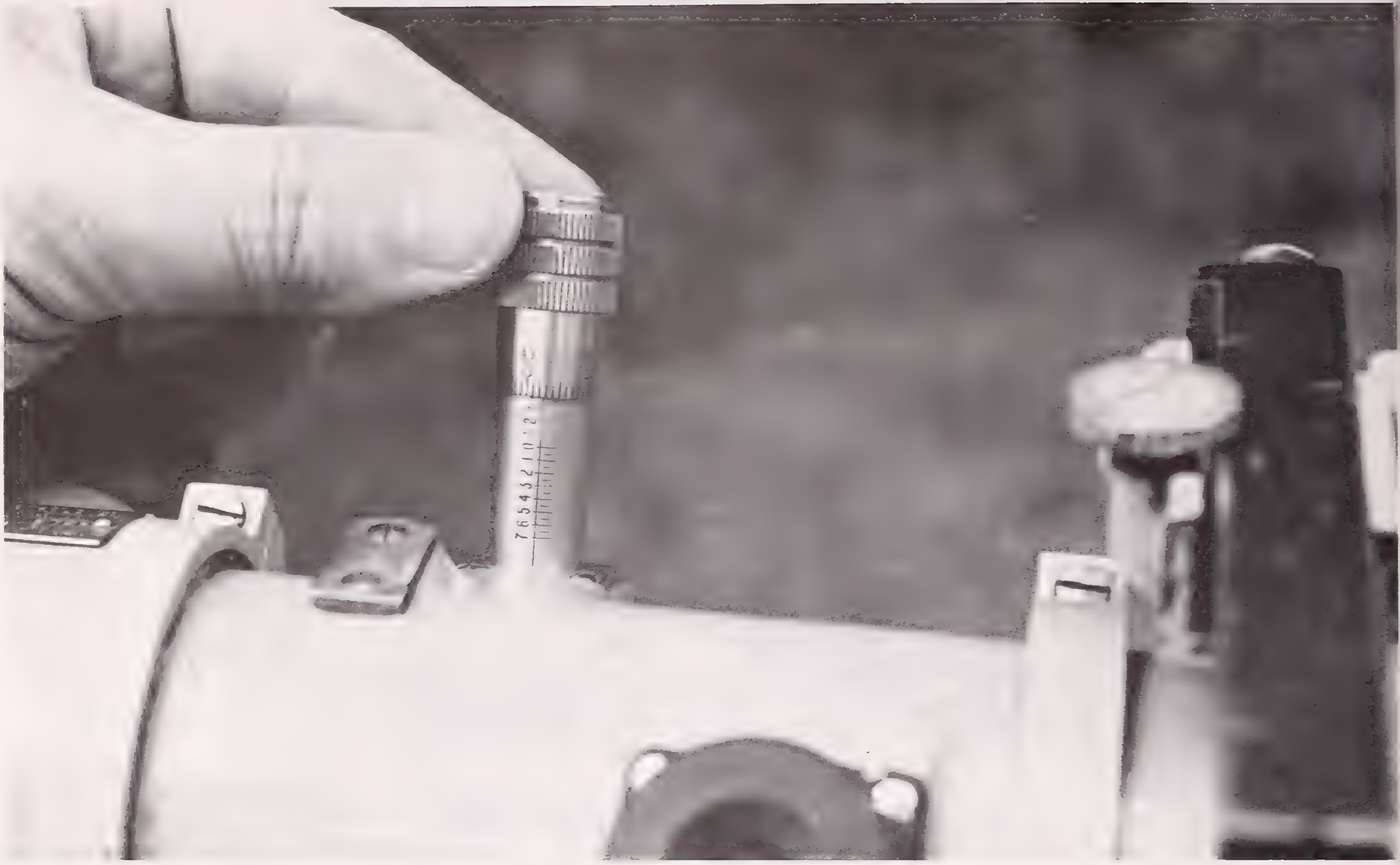


Figure 16.–Barr and Stroud model FP-12 micrometer adjustment for reading elevation changes.

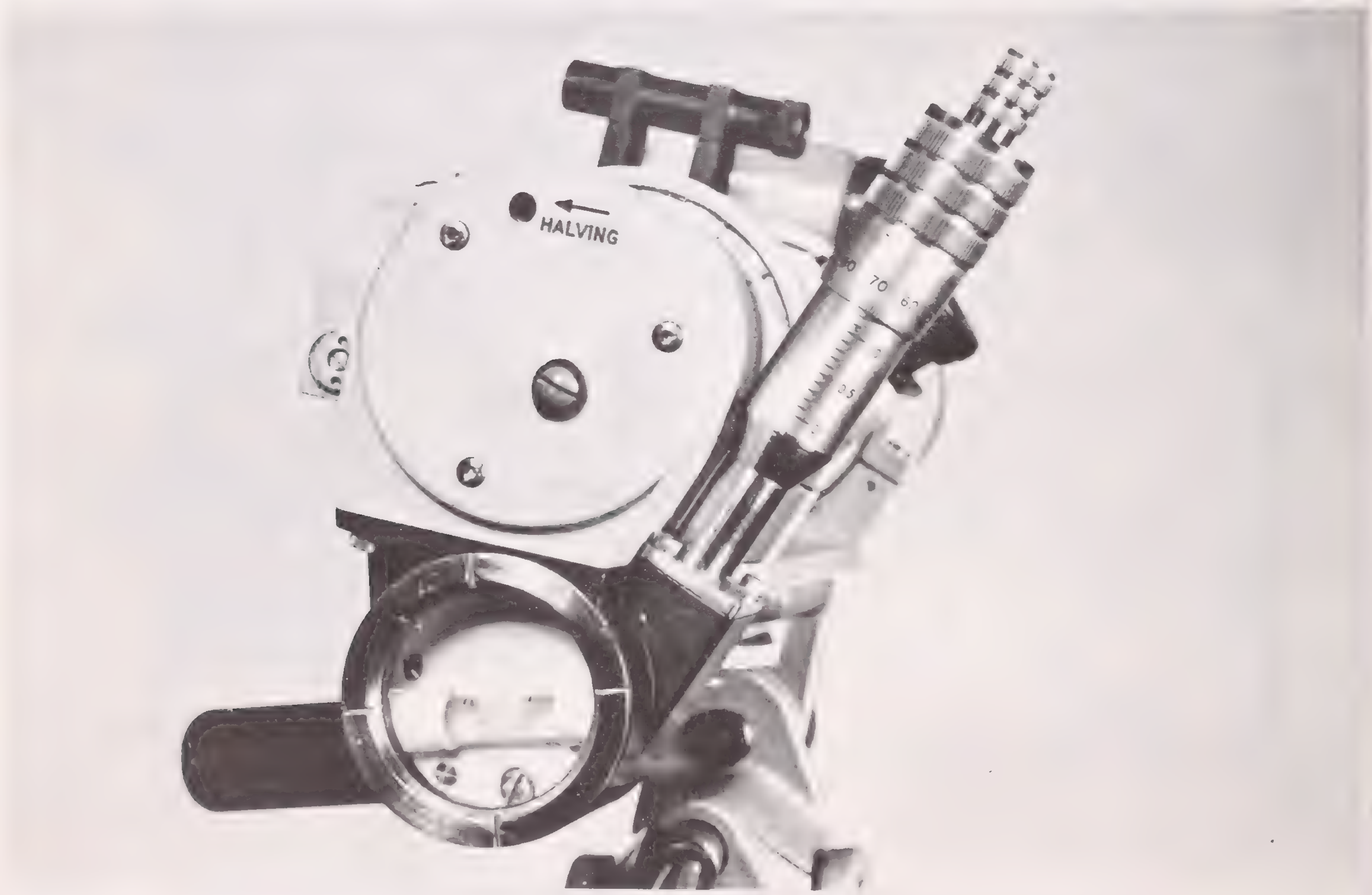


Figure 17.–Barr and Stroud model FP-15 micrometer adjustment for reading elevation changes.

Direct Reading Dendrometry (Option 2)

Record in column 23 of tree data card.

This option is useful for several instruments that can read diameters and segment heights directly, but is best suited for use with felled tree measurements or climbing.

The TGRADS columns are not used when using Option 2, Direct Measurement. The diameters determined at each point are entered in the FGRADS and the length of each segment in the SINELV columns.

Felled tree and climbing measurements are taken with either a diameter tape or calipers at each segment, product, or taper change. The diameter and length for each measurement is recorded as shown on figure 18; computer output is shown on figure 19.

The felled tree procedure works well for the sample trees selected when determining the volume of timber to be harvested; obviously this procedure would not be used for forest inventory. Climbing may be used in either situation; however, it is time consuming and dangerous.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★= (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1	35	1	*	D11RE	105	2	2	1	0	.6	.4		

XTRA 42–56

XTRB 57–71

Percent or Volume Deduction 73–76

CFI Point No. 77–80: 2

Dendrometry Data

TREE NO. (1–4): 1 J (5)

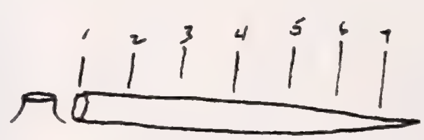
J	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	72
1	12		16	13.5	20	0.0	25		
	27		31	10.5	35	4.0	40	PW	
	42		46	9.4	50	4.7	55	PW	
	57		61	8.2	65	7.1	70	PW	
2	12		16	8.2	20	5.3	25	PW	
	27		31	7.7	35	3.5	40	PW	
	42		46	5.7	50	3.6	55	PW	
	57		61		65		70		*
3	12		16		20		25		
	27		31		35		40		
	42		46		50		55		
	57		61		65		70		
4	12		16		20		25		
	27		31		35		40		
	42		46		50		55		
	57		61		65		70		

Cols. 1–4, 73–80 are in every card.

GROWTH 73–76: .45

CFI POINT NO. 77–80: 2

Sketch tree below



LEAN deg.

For unseen material, total tree ht. ______ unseen merch. length ______ rate of taper ______

Dendrometer set up: bearing ______ distance ______

2–78 CC

Figure 18.–Example of direct measurement recording procedure for a measured tree.

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DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE   5
CRC 8-04-80                                    2    400.   160       15467 123020
                     DETAILED LOG AND/OR TREE REPORT
==================================================================================
TREE/  VOLUME  / SURFACE / LENGTH /  DIR    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /   FT.  /  IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
==================================================================================
            .8        5.9       3.6        5.3   PW       .0       .0     5.7    3.6000
           1.0        6.7       3.5        7.1   PW       .0       .0     7.7    3.5000
           1.7       10.5       5.3        7.6   PW       .0       .0     8.2    5.3000
           2.5       15.0       7.1        7.6   PW       .0       .0     8.2    7.1000
           2.1       11.1       4.7        8.6   PW       .0       .0     9.4    4.7000
           2.5       11.1       4.0        9.5   PW       .0       .0    10.5    4.0000
            .0         .0        .0       11.7            .0       .0    13.5     .0000
----------------------------------------------------------------------------------
   1 SUMS  10.5       60.3     28.2  /  10.5 = D.B.H.    FREQUENCY =        1180.750
     PREDICTION =   35  D.B.T. =  1.00  FORK   OPTIONS = 2210 UNSEEN MATERIAL
     CLASS = DIRE   VALUE STRATUM =  1   BASAL AREA =    .60
     PLOT OR POINT NUMBER      2   GROWTH =     .45
**********************************************************************************
```

Figure 19.–Computer printout from direct reading dendrometry (option 2).

Zeiss Teletop Dendrometer (Option 3)

Record in column 23 of tree data card. Mesavage (1969) provides pertinent information on the use of this instrument. Examples of data recording and STXMOD computer output are in figures 20 and 21, respectively.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JQB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1	100	1	*	ZEIS	18.0	3	2	1	0	.7	.8		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	3

Dendrometry Data

TREE NO. (1–5) J

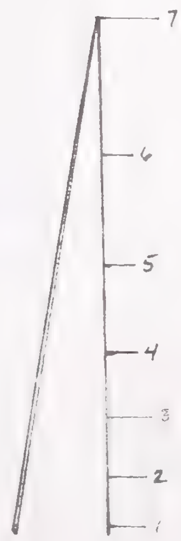
J	T GRADS	F GRADS	SINELV	GR		
1	12 -999	16 210	20 4.0	25		
	27	31 180	35 8.0	40 5	T	
	42 1007	46 170	50 93.2	55 5	T	72
	57 1500	61 170	65 100.0	70 7	W	
2	12 1542	16 140	20 113.5	25 7	W	
	27 1581	31 120	35 119.2	40 7	W	
	42 -999	46 -999	50 133.3	55 7	W	72
	57	61	65	70		*
3	12	16	20	25		
	27	31	35	40		
	42	46	50	55		72
	57	61	65	70		
4	12	16	20	25		
	27	31	35	40		
	42	46	50	55		72
	57	61	65	70		

Cols. 1-4, 73-80 are in every card

GROWTH (73–76)	CFI POINT NO. (77–80)
.55	3

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 CC

Figure 20.–Example of data recorded for measurements obtained with the Zeiss Teletop (option 3).

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DENDROMETRY EXAMPLES AND OPTIONS                                        TEST  PAGE   6
CRC 8-04-80                                       2     400.   160      15467 123020
                         DETAILED LOG AND/OR TREE REPORT
=====================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /   DIB    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /   IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
=====================================================================================
             10.7       68.4     46.1         .1   TW      .0   -99.9   -99.9   33.3000
             12.9       50.9     16.0       11.2   TW   158.1   158.1    12.0   19.2000
             40.6      135.3     36.0       13.0   TW   154.2   154.2    14.0   13.5000
             15.9       48.9     11.9       15.7   TW   150.0   150.0    17.0     .0000
             11.3       33.7      8.0       15.7   ST   100.7   100.7    17.0   -6.8000
              6.8       18.5      4.0       16.5   ST      .0      .0    18.0    8.0000
               .0         .0       .0       18.9   ST      .0   -99.9    21.0    4.0000
-------------------------------------------------------------------------------------
   1 SUMS  98.2      355.7    122.0  /  18.0 = D.B.H.    FREQUENCY =          140.624
     PREDICTION =  100   D.B.T. =  1.50  FORK   OPTIONS = 3210 UNSEEN MATERIAL
     CLASS = ZEIS   VALUE STRATUM =  1   BASAL AREA =  1.77
     PLOT OR POINT NUMBER     3   GROWTH =     .55
*************************************************************************************
```

Figure 21.–STXMOD computer output from data recorded with Zeiss Teletop (option 2).

Transit Dendrometer (Option 4)

Record in column 23 of tree data card. Like any transit instrument, the transit dendrometer must be level before any readings are taken. Most transit dendrometer instruments have just a bull's eye bubble for leveling. The horizontal distance from the center of the tree to the instrument must be known before any tree measurements can be made. Determine the distance by either stadia or actual measurement with a tape from the instrument to the center of the tree at d.b.h. When using stadia, the horizontal scale shown in figure 23 is calibrated for 1 foot at 100 feet distance; therefore, when the distance is more or less than 100 feet, the stadia reading is a fraction or percent of 100. For example, if the instrument is 85 feet from the center of the tree, the stadia reading should be .85. Use this figure to calculate both the diameter and the height when the tree measurements are taken. Record the distance entry in the first FGRAD column of the dendrometry sheet. To adjust this slope measurement for horizontal distance, the angle in degrees and minutes is entered in SINELV column. Example: 13 degrees 15 minutes is entered as 1315. It is not necessary to enter either a "+" or "–" for this reading, but it can be done at the recorder's option.

When determining the distance by either stadia or actual measurement, measure along the line of sight from the instrument to the d.b.h. of the tree (i.e., slope distance). Calculate and use the horizontal distance with all other measurements taken up the tree.

Determine the diameter by the number of vertical scribes along the center horizontal scale (figure 23). The scale is calibrated for .5 inch, 1 inch, and 6 inches at 100 feet. The 6-inch scale is for ease of reading and counting the 1-inch scale. When determining the diameter of a tree, the 1-inch scale is counted across the tree to the closest .5 inch. Record this figure in the FGRAD column as follows: 12½ 1-inch scales would be recorded as 12.5. The angle from the instrument to the measuring point on the tree is recorded in the SINELV column the same as discussed earlier; however, if the reading is "–" (minus), it *must* be entered in the first column of SINELV. Example: –1400. It is not necessary to enter a "+", but it may be done if desired.

Leaning trees are measured 90 degrees to the direction of the lean. Record the degree of lean in the TGRAD column to the nearest degree (no minutes). Calculate the correct length of segment and diameter from this entry.

When a "+" is used in column 72 to indicate the instrument has been moved, or that a forked tree is involved, the distance from the tree must be established again by either measuring the actual distance or by stadia and entering the bearing (degrees) of line of sight from the instrument to d.b.h.

If the lean is recorded for the first set of numbers in a series, then the length of the first segment of wood is extended downward by the STXMOD program. This procedure is desirable for branches and forks. The program does not do this for the very first segment in a tree, as any lean in the first two wood segments are corrected by the two hand measurements. The length process can be overridden by recording a negative lean in the TGRADS (figure 29).

The directions in the following paragraphs and figures 24 to 30, shown in ascending order of difficulty, give added emphasis to the principal points discussed earlier on the transit dendrometer.

The stadia *must* be the first set of numbers for each series, i.e., as the very first set of numbers for any tree and as the first set of numbers following any "+" sign (column 72). Put the stadia reading (feet and hundredths) into the FGRADS, and the stadia angle (degrees in first 3 columns; minutes in last 2 columns) into SINELV. A minus sign may be recorded in SINELV for any negative readings. The TGRADS are not used for the stadia. The implicit format for the stadia reading (FGRADS) is F4.1. The "6" in figure 26 could have been explicitly recorded as "0.60" (feet and hundredths).

The two hand measurements (stump and d.b.h.) are recorded and flagged with the –999 in TGRADS. (See figure 25; figure 28 has no hand measurement.) The FGRADS are used to record the diameter in terms of the number of

vertical marks (as seen through the transit scope) that line up across the tree. Record these to the nearest 10th. (Again, the implicit format for any FGRADS is F4.1. Figure 26 shows the first dendrometer reading as 81, which is 8.1 vertical marks. The two hand mesurements correspond to 6.9 and 6.1 inches).

The angle of the reading (not to be confused with the "lean") is recorded in SINELV, degrees in the first three columns and minutes in the last two columns. A negative reading *must* be indicated with a minus (–) sign.

Lean is recorded in the TGRADS. The lean pertains to the next piece of wood *above* the dendrometer reading. Corrections are made by the program for both the length and lower (i.e., larger) diameter of a leaning piece, and should be taken at a location where the lean exists (see figures 24A, 24B, 26, 27 and 29). In other words, the diameter recorded should be larger than the true diameter.

The transit dendrometer measurements may be taken directly, with some minor calculations done in the field. The horizontal distance from the center of the tree to the instrument must be known and can also be determined by either stadia or actual measurements. However, the distance must be horizontal, or calculated in the field.

Determine the diameter by reading the horizontal scale as discussed previously, and then multiply it by the distance. Example: 12.5 x .85 = 10.6 inches. In addition to this, there is a diameter correction factor to allow for the added distance to the tree as the angle increases when measurements are taken up the tree. This factor is scribed on the vertical scale of the instrument and is used to adjust the above reading (figures 22 and 32). For example, if the sighting angle was 20 percent (or 11° 30′), the "diameter correction factor" would be "1.02"; then the corrected diameter is: 12.5 x 1.02 x .85 = 10.84 inches. The height is determined from the "percent grade" scale multiplied by the distance. Example: 20 percent x .85 = 17.0 feet. (When using this procedure, you would not use the STX-MOD computer program or only make spot checks of the instrument readings.)

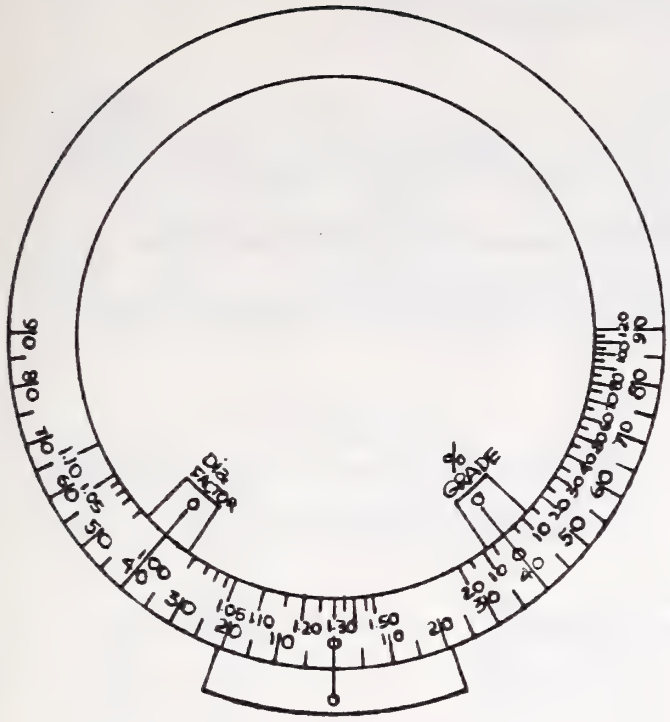


Figure 22.–Scale drawing of Transit dendrometer vertical circle showing the percent grade scale and the diameter factor scale.

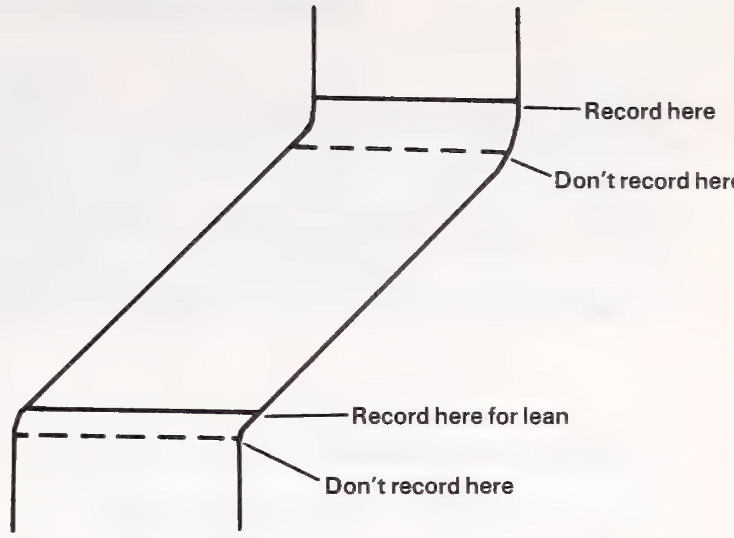


Figure 24A.–If a lean is recorded for the first set of numbers in a series, then the length of the first segment of wood is extended downward by the program. This is desirable for branches and forks (see figure 27).

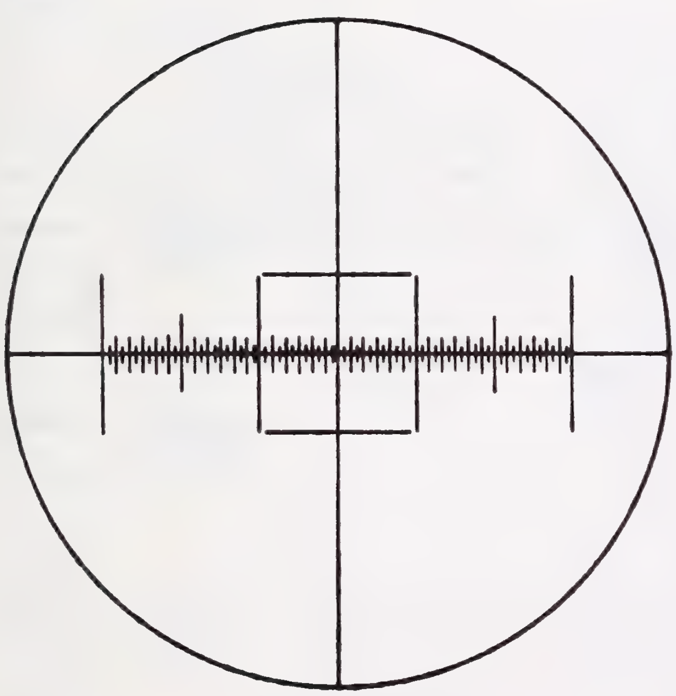


Figure 23.–The diameter and statia scale. The scale is 1 foot at 100 feet distance.

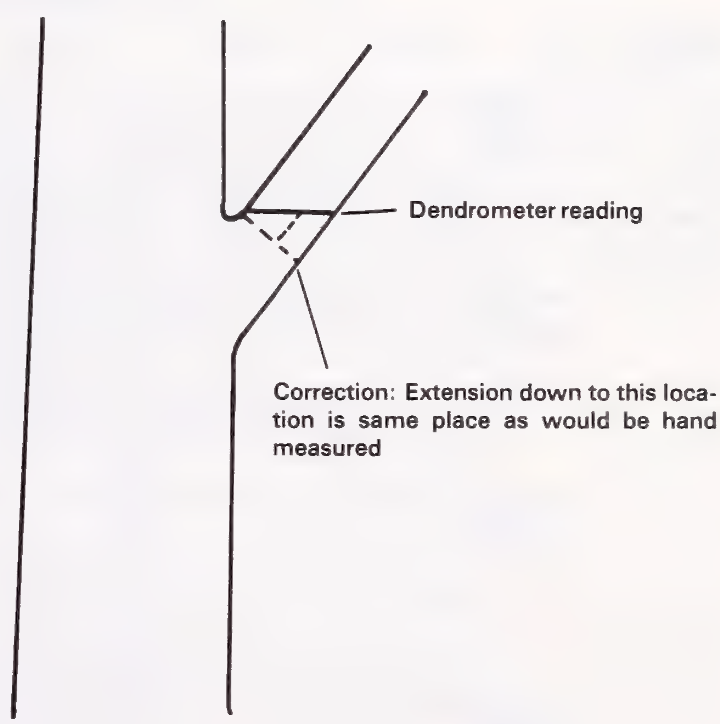


Figure 24B.–The process shown in figure 24A can be overridden by recording a negative lean in the TGRADS. Figure 29 involved movement of the transit on a leaning tree. The "extension" downward was not applicable, so a -30 was recorded in the TGRADS instead of +30.

SAMPLE TREE
RECORDING SHEET FOR STX

Tree Data

DATE ____________________ ____________________ CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1		1	=	10	6.9	4	2		4	.8	.7		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)

Dendrometry Data

TREE NO. (1–4): 1   J (5)

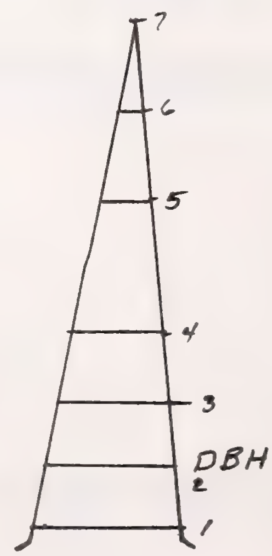
Cols. 1-4, 73-80 are in every card.

J	T GRADS	F GRADS	SINELV	GR	72
1	12:	16: .60	20: 119	25:	
	27: -999	31: 6.9	35: 3.5	40:	
	42:	46: 6.1	50: 4.5	55: PW	
	57:	61: 8.1	65: 305	70: PW	
2	12:	16: 6.2	20: 1259	25: PW	
	27:	31: 3.5	35: 2518	40: PW	
	42: -999	46: -999	50: 3430	55: PW	
	57:	61:	65:	70:	*
3	12:	16:	20:	25:	
	27:	31:	35:	40:	
	42:	46:	50:	55:	
	57:	61:	65:	70:	
4	12:	16:	20:	25:	
	27:	31:	35:	40:	
	42:	46:	50:	55:	
	57:	61:	65:	70:	

GROWTH (73–76)	CFI POINT NO. (77–80)

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2–78 CC

Figure 25.–Example of transit dendrometer recordings of a normal tree, with first two sets of measurements being physical.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE ______________ **Tree Data** ______________ CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
2		1	=	110	69	4	2		4	.8	.7		

XTRA (42–56) ______________

XTRB (57–71) ______________

Percent or Volume Deduction (73–76) ______

CFI Point No. (77–80) ______

Dendrometry Data

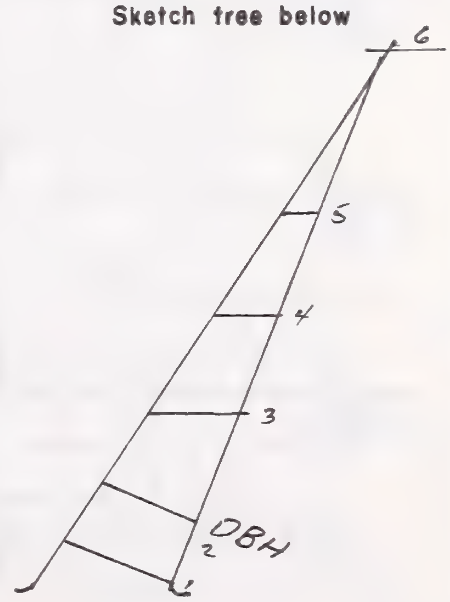
TREE NO. (1–4) J (5) T GRADS F GRADS SINELV GR LEAN deg.

Cols. 1-4, 73-80 are in every card.

J	Cols.	T GRADS	F GRADS	SINELV	GR	
1	12 / 16 / 20 / 25		6	119		
	27 / 31 / 35 / 40	-999	69	3.5		
	42 / 46 / 50 / 55		61	4.5	PW	72
	57 / 61 / 65 / 70	40	81	305	PW	
2	12 / 16 / 20 / 25	40	62	1259	PW	
	27 / 31 / 35 / 40	40	35	2518	PW	
	42 / 46 / 50 / 55	-999	-999	3430	PW	72
	57 / 61 / 65 / 70					*
3	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					72
	57 / 61 / 65 / 70					
4	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					72
	57 / 61 / 65 / 70					

GROWTH (73–76) ______ CFI POINT NO. (77–80) ______

Sketch tree below



For unseen material, total tree ht. ______ unseen merch. length ______ rate of taper ______

Dendrometer set up: bearing ______ distance ______

2-78 CC

Figure 26.–Example of transit dendrometer recordings of a leaning tree, with first two sets of measurements being physical.

SAMPLE TREE RECORDING SHEET FOR STX

Tree Data

DATE ______________________ ______________________ CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S t r. (10)	★ (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
3		1	=	110	18.2	4	2		0	1.1	1.3		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)

Dendrometry Data

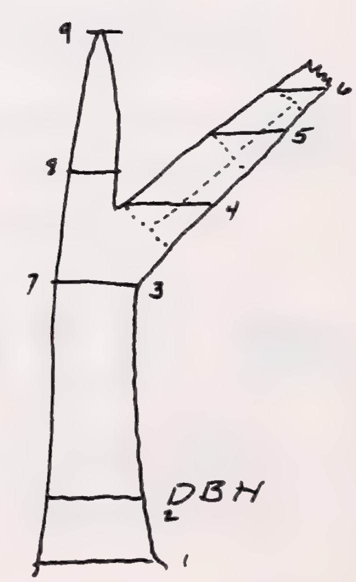
TREE NO. (1–4)	J (5)	Col.	T GRADS	F GRADS	SINELV	GR	72
3	1	12		.67	-38		
		27	-999	21.4	4.5		
		42		18.2	4.5	5 T	
		57		20.9	1503	5 T	+
	2	12		.67	-38		
		27	30	17.2	1558		
		42	30	13.8	2017	P W	
		57	30	8.6	2346	P W	+
	3	12		.67	-38		
		27		20.9	1503		
		42		11.8	2814	5 T	
		57	-999	-999	3636	P W	*
	4	12					
		27					
		42					
		57					

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _______

Dendrometer set up: bearing _______ distance _________

2-78 CC

Figure 27.–Example of transit dendrometer recordings of a forked tree, with the first two sets of measurements being physical.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE ______________ **Tree Data** ______________CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
4		1	=	10	13.2	4	2		6	1.0	1.2		

XTRA (42–56): ______________

XTRB (57–71): ______________

Percent or Volume Deduction (73–76): ______

CFI Point No. (77–80): ______

Dendrometry Data

TREE NO. (1–4): 4 J (5): 1

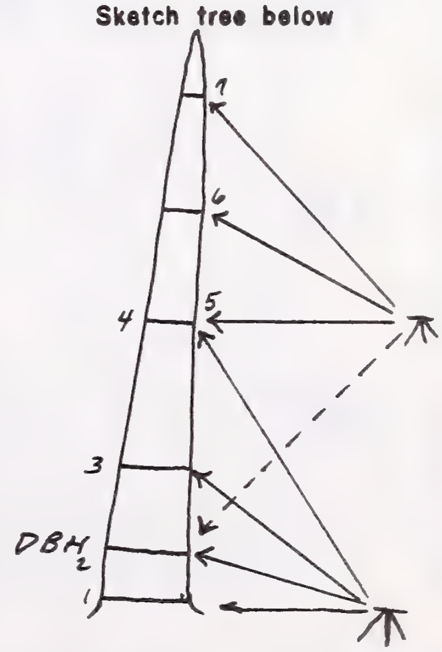
Cols. 1-4, 73-80 are in every card.

Card	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	72
1	12		16	7.01	20	512	25		
	27		31	76.0	35	00	40		
	42		46	73.2	50	520	55	ST	
	57		61	9.1	65	1631	70	ST	
2	12		16	7.2	20	2419	25	PW	
	27		31		35		40		
	42		46		50		55		
	57		61		65		70		+
3	12		16	.51	20	-2619	25		
	27		31	74.4	35	147	40		
	42		46	8.3	50	1557	55	PW	
	57		61	6.1	65	2214	70	PW	*
4	12		16		20		25		
	27		31		35		40		
	42		46		50		55		
	57		61		65		70		

GROWTH (73–76): ______ CFI POINT NO. (77–80): ______

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _______

Dendrometer set up: bearing _______ distance _________

2-78 CC

Figure 28.–Example of transit dendrometer recordings of a tree where the instrument was moved, instrument was used from bottom to top.

SAMPLE TREE RECORDING SHEET FOR STX

DATE ______________ **Tree Data** ______________ CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	* = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
5		1	=	110	8.0	4	2		4	.9	.8		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)

Dendrometry Data

TREE NO. (1–4): 5 J (5): 1

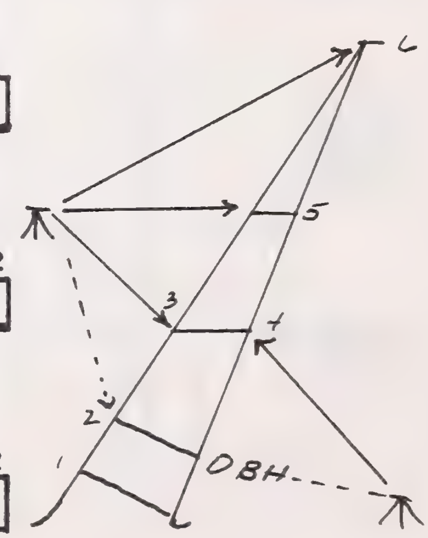
Cols. 1-4, 73-80 are in every card.

Card	T GRADS	F GRADS	SINELV	GR	
1	12	16 .83	20 21	25	
	27 -999	31 10.0	35 4.5	40	
	42	46 8.0	50 4.5	55 PW	72
	57 30	61 8.4	65 1516	70 PW	+
2	12	16 .79	20 -1832	25	
	27 -30	31 8.8	35 -513	40	
	42 30	46 6.3	50 816	55 PW	72
	57 -999	61 -999	65 2131	70 PW	*
3	12	16	20	25	
	27	31	35	40	
	42	46	50	55	72
	57	61	65	70	
4	12	16	20	25	
	27	31	35	40	
	42	46	50	55	72
	57	61	65	70	

GROWTH (73–76)	CFI POINT NO. (77–80)

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _______

Dendrometer set up: bearing _______ distance _______

2-78 CC

Figure 29.–Example of transit dendrometer recordings for a leaning tree where instrument was moved, with the first two sets of measurements being physical.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
3	55	2	*	TRAN	26.6	4	3	1	0	1.3	1.3		

XTRA 42–56

XTRB 57–71

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	4

Dendrometry Data

Cols. 1-4, 73-80 are in every card.

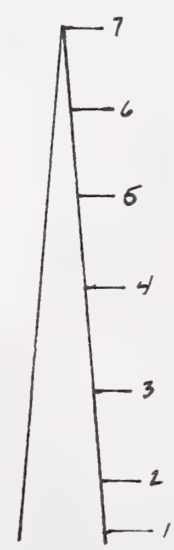
TREE NO. (1) 3 — J (5)

J	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	
1	12		16	.856	20	105	25		
	27	-999	31	32.4	35	3.5	40		
	42		46	26.6	50	5.0	55	ST	72
	57		61	28.0	65	435	70	ST	
2	12		16	26.5	20	1008	25	ST	
	27		31	25.5	35	1630	40	ST	
	42		46	22.0	50	2420	55	ST	72
	57		61	-999	65		70	7W	*
3	12		16		20		25		
	27		31		35		40		
	42		46		50		55		72
	57		61		65		70		
4	12		16		20		25		
	27		31		35		40		
	42		46		50		55		72
	57		61		65		70		

GROWTH (73–76)	CFI POINT NO. (77–80)
.7	4

LEAN deg.

Sketch tree below



For unseen material, total tree ht. ______ unseen merch. length ______ rate of taper ______

Dendrometer set up : bearing ______ distance ______

2–78 CC

Figure 30.–Example of transit dendrometer recording where the projection of Unseen Merchantable Material Option is used.

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DENDROMETRY EXAMPLES AND OPTIONS                                     TEST  PAGE   6
CRC 8-04-80                                      2    400.  .160      15467 123020
                      DETAILED LOG AND/OR TREE REPORT
==================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /  DIB    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /  IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
==================================================================================
             5.6      19.0      4.3      3.3  TW      .0      .0 -99.90      .0000
            28.0      68.9     13.5     18.4  ST    95.1      .0  22.00      .2420
            23.7      55.0     10.2     20.5  ST    90.4      .0  25.50      .1630
            21.1      47.6      8.5     20.8  ST    88.1      .0  26.50      .1008
            14.3      30.0      5.0     21.8  ST    87.0      .0  28.00      .0435
            14.0      24.7      3.5     24.0  ST      .0      .0  26.60     5.0000
              .0        .0       .0     30.0              .0   -99.9  32.40     3.5000
----------------------------------------------------------------------------------
   3 SUMS 106.6      245.2     45.1   /  26.6 = D.B.H.    FREQUENCY =      107.970
     PREDICTION =    55  D.B.T. =  2.60  FORK   OPTIONS = 4310 UNSEEN MATERIAL *
     CLASS = TRAN    VALUE STRATUM =  2   BASAL AREA =  3.86
     PLOT OR POINT NUMBER      4   GROWTH =     .70
**********************************************************************************
```

Figure 31.–Example of printout from figure 30, showing projected top.

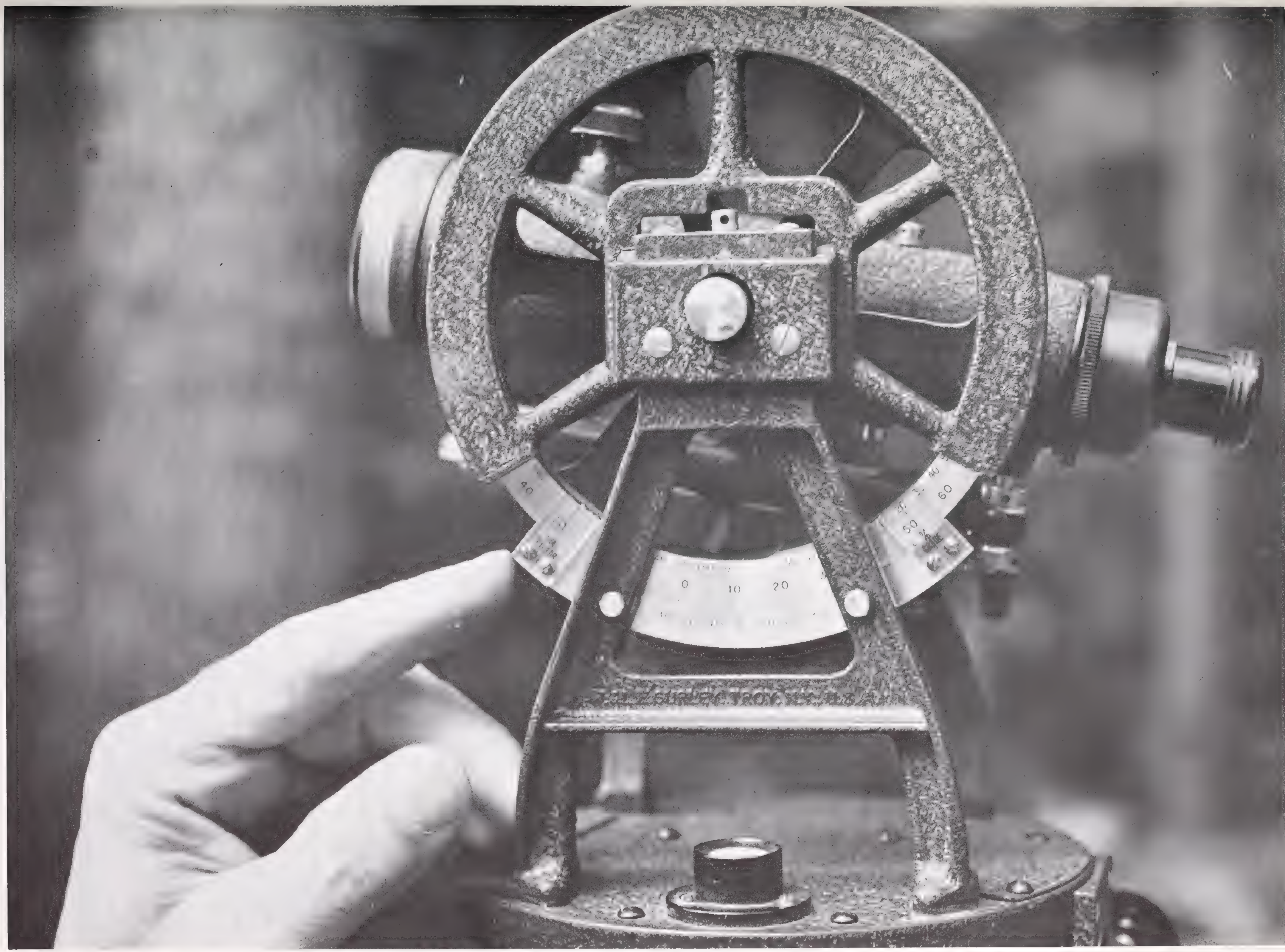


Figure 32.–Transit Dendrometer: Note the additional scales of Percent and Diameter Correction which are used when hand calculations are performed.

American Scale Relaskop (Option 5)

Record in column 23 of tree data card.

The Relaskop has proven to be a very versatile instrument, and provides good results when used as a dendrometer. In the TGRADS, the distance from the center of the tree to the instrument is recorded in feet and tenths; this distance is entered for each measurement (figure 33). Figure 34 displays a printout of the data entered on figure 33. In the FGRADS, the number of Relaskop units and tenths of units are entered as a diameter factor. The SINELV is a plus or minus figure from the percent scale and entered to the nearest tenth of unit with a decimal. The recorded decimal in the TGRADS and FGRADS is not necessary but does provide ease of reading.

Determining Diameter

The scale between "a" and "b" on figure 35A and 35B is divided into six equal-width bars (three light and three dark). The projection of the distance "a" to "b;" is equal to:

1 foot (each bar 2 inches) at a horizontal distance of 33 feet.
2 feet (each bar 4 inches) at a horizontal distance of 66 feet.
3 feet (each bar 6 inches) at a horizontal distance of 99 feet.
4 feet (each bar 8 inches) at a horizontal distance of 132 feet.

The distance between "0" and "10" on the scale equals the distance between "a" and "b". Similarly, the distance between "10" and "a" equals the distance between "a" and "b". At 33 feet, "a" to "b" intercepts 12 diameter inches. Thus, to measure the diameter of a tree with a d.b.h. of 34 inches, position the Relaskop 33 feet from the tree and set the "0" edge of the scale on the left bark edge of the tree. The scale "0" to "10" will intercept 12 diameter inches: "10" to "a" will intercept another 12 diameter inches and the right bark edge will align with the right edge of the fifth bar between "a" and "b" for 10 more diameter inches. Total, 12 + 12 + 10=34 inchers diameter. In this case, the diameter can be read to the nearest full bar between "a" and "b" (estimates may be made to the nearest tenth bar).

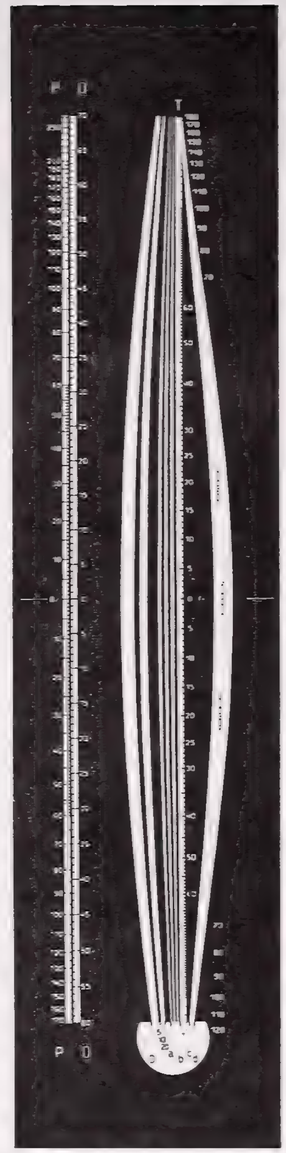


Figure 35A.–American scales, full view.

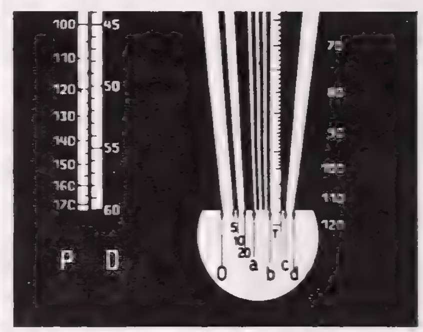


Figure 35B. –Lower part of American scale, enlarged to show identification of graduations.

By positioning the Relaskop at other distances such as 66, 99, and 132 feet, different valuers apply. When using the STXMOD computer program, any distance that provides a good view of the tree bole is acceptable by entering the distance in the TGRADS column for each measurement taken.

Because the instrument is self-adjusting for change in slope, the diameter at any height above the ground may be determined without correcting for slope. An example of the Relaskop in use is given in figure 36.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. 1–4	Ht. or Vol. 6–9	Sr. 10	★ = 11	Class 12–15	D. B. H. 17–21	Opt. M 23	Opt. B 24	Opt. U 25	Opt. I 26	Bark A 27–30	Bark B 31–34	UML 36–38	UDT 39–41
1	75	2	*	RELA	16.5	5	3	1	0	.5	.4		

XTRA 42–56	XTRB 57–71

Percent or Volume Deduction 73–76	CFI Point No. 77–80
	5

Dendrometry Data

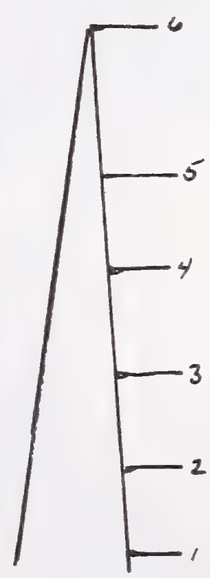
TREE NO. 1–4	J 5	T GRADS	F GRADS	SINELV	GR	72
1	1	12: 68.5	16: 4.5	20: -1.0	25:	
		27: 68.5	31: 4.2	35: 4.5	40: ST	
		42: 68.5	46: 3.0	50: 6.0	55: ST	
		57: 68.5	61: 2.0	65: 35.0	70: ST	
	2	12: 68.5	16: 1.5	20: 61.0	25: TW	
		27: -999	31: -999	35: 70.0	40: TW	
		42:	46:	50:	55:	
		57:	61:	65:	70:	*
	3	12:	16:	20:	25:	
		27:	31:	35:	40:	
		42:	46:	50:	55:	
		57:	61:	65:	70:	
	4	12:	16:	20:	25:	
		27:	31:	35:	40:	
		42:	46:	50:	55:	
		57:	61:	65:	70:	

Cols 1-4, 73-80 are in every card.

GROWTH 73–76	CFI POINT NO. 77–80
.5	5

LEAN deg

Sketch tree below



For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2-78 CC

Figure 33.–Example of Relaskop Dendrometer recordings, measurements with instrument started from the stump.

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DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE   5
CRC 8-04-80                                       2     400.  160      15467 123020
                     DETAILED LOG AND/OR TREE REPORT
===================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /   DIB    / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /   IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
===================================================================================
                .5       6.8       9.3         .1    TW       .0   -99.9   -99.9    70.0000
               6.2      45.7      27.0        5.5    TW     93.3    68.5     1.5    61.0000
              14.9      74.5      30.1        7.4    ST     77.5    68.5     2.0    35.0000
               1.7       5.7       1.6       11.5    ST     68.8    68.5     3.0     6.0000
               9.3      25.8       5.7       16.6    ST     68.7    68.5     4.2     4.5000
                .0        .0        .0       17.9           68.5    68.5     4.5    -1.0000
-----------------------------------------------------------------------------------
   1 SUMS  32.6      158.5      73.7  /  16.5 = D.B.H.    FREQUENCY =        205.779
     PREDICTION =     75  D.B.T. =    .90  FORK   OPTIONS = 5310 UNSEEN MATERIAL
     CLASS = RELA    VALUE STRATUM =  2    BASAL AREA =  1.48
     PLOT OR POINT NUMBER      5   GROWTH =     .50
***********************************************************************************
```

Figure 34.–Example of printout from figure 33.

(Figures 35A and 35B appear on page 52)

Figure 36.–Relaskop in use.

Direct Reading Calipers

100-foot Base Caliper (Option 6)

Record in column 23 of tree data card.

Some of the direct reading dendrometers are:

- Wheeler pentaprism caliper (figures 40-41)
- McClure mirror caliper
- Transit dendrometer (when field calculating is done)
- Tele-Relaskop (used when measurements are taken in the same unit as the instrument or conversion tables are used)
- Direct measurement, i.e., fallen or down trees

1. Optical caliper readings. See figure 37.

   TGRADS – May be left blank when 100.0 feet is assumed, otherwise enter the horizontal distance from the instrument to the center of the tree in feet and tenths of feet for each set of measurements taken (format F4.1).

   FGRADS – Enter the diameter in inches and tenths of inches as read from the direct reading caliper or the actual taped diameter (format F4.1).

   SINELV – Height measurements are entered as a percent reading for each segment in percent units and tenths; for reading below horizontal, enter a minus (–) preceding the reading (format F5.4).

2. Direct measurements of down trees

   TGRADS – Leave blank (100.0) feet is assumed).

   FGRADS – Taped or calipered diameter is entered in inches and tenths.

   SINELV – Length to each point of measurement from the base is entered in feet and tenths (format F5.4).

The TGRADS (distance from instrument to tree) may vary from one trio of measurements to another as long as the height of the instrument (clinometer) does not vary. If the elevation of the clinometer does change, put a plus (+) in column 72 (TERM) of that card and start a new card. The first trio of measurements on the new card must be at the same point as the last measurements to form a new base (figures 37 and 38). The computer output is shown in figure 39.

66-foot Base Caliper (Option 7)

Record in column 23 of the tree data card. All procedures for option 7 are the same as for option 6, except the height is calculated on the basis of a 66-foot base. See figure 38. The computer output is shown in figure 39.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1	90	2	*	C100	20.5	6	2	1	0	.3	.4		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	6

Dendrometry Data

TREE NO. (1–4): 1 J (5): 1

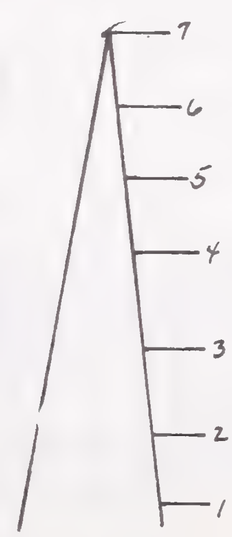
J	T GRADS	F GRADS	SINELV	GR	72
1	90.0	27.5	-8.0		
	90.0	20.5	1.0	ST	
	90.0	18.1	16.0	ST	
	90.0	14.3	30.0	ST	
2	90.0	10.0	60.0	ST	
	90.0	6.1	80.0	TW	
	90.0	.2	92.0	TW	
					*
3					
4					

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)
.4	6

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2–78 CC

Figure 37.–Example of Direct Reading Caliper recordings using a 100 foot base (percent).

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Sr. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1	90	2	*	966	20.5	7	2	1	0	.3	.4		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	7

Dendrometry Data

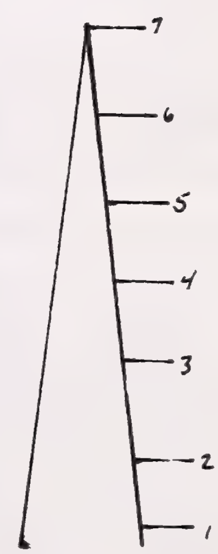
TREE NO. (1–4)	J (5)	T GRADS	F GRADS	SINELV	GR		72
1	1	12: 90.0	16: 27.5	20: -8.0	25:		
		27: 90.0	31: 20.5	35: 1.0	40: 5	T	
		42: 90.0	46: 18.1	50: 16.0	55: 5	T	
		57: 90.0	61: 14.3	65: 30.0	70: 5	T	
	2	12: 90.0	16: 10.0	20: 60.0	25: 5	T	
		27: 90.0	31: 6.1	35: 80.0	40: 7	W	
		42: 90.0	46: .2	50: 92.0	55: 7	W	
		57:	61:	65:	70:		*
	3	12:	16:	20:	25:		
		27:	31:	35:	40:		
		42:	46:	50:	55:		
		57:	61:	65:	70:		
	4	12:	16:	20:	25:		
		27:	31:	35:	40:		
		42:	46:	50:	55:		
		57:	61:	65:	70:		

Cols. 1-4, 73-80 are in every card

GROWTH (73–76)	CFI POINT NO. (77–80)
	7

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2–78 CC

Figure 38.–Example of Direct Reading Calipor recordings, using a 66-foot base (percent).

```
DENDROMETRY EXAMPLES AND OPTIONS                                  TEST  PAGE   7
CRC 8-04-80                                   2     400.  160     15467 123020
                    DETAILED LOG AND/OR TREE REPORT
==================================================================================
TREE/  VOLUME  / SURFACE / LENGTH /  DIB    / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /   FT.  /  IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
==================================================================================
             .7       8.7     10.8       .2    TW       .0     90.0      .2   92.0000
            6.2      37.1     18.0      6.0    TW       .0     90.0     6.1   80.0000
           20.9      83.8     27.0      9.8    ST       .0     90.0    10.0   60.0000
           17.1      51.9     12.6     13.9    ST       .0     90.0    14.3   30.0000
           25.7      66.0     13.5     17.5    ST       .0     90.0    18.1   16.0000
           23.4      48.6      8.1     19.8    ST       .0     90.0    20.5    1.0000
             .0        .0       .0     26.1             .0     90.0    27.5   -8.0000
----------------------------------------------------------------------------------
  1 SUMS  94.0     296.1     90.0  /  20.5 = D.B.H.   FREQUENCY =         111.091
    PREDICTION =    90  D.B.T. =   .70  FORK   OPTIONS = 6210 UNSEEN MATERIAL
    CLASS = C100    VALUE STRATUM =  2   BASAL AREA =  2.29
    PLOT OR POINT NUMBER      6   GROWTH =     .40
**********************************************************************************
            1.1      13.2     16.4       .2    TW       .0     90.0      .2   92.0000
            9.4      56.2     27.3      6.0    TW       .0     90.0     6.1   80.0000
           31.7     126.9     40.9      9.8    ST       .0     90.0    10.0   60.0000
           25.9      78.6     19.1     13.9    ST       .0     90.0    14.3   30.0000
           38.9     100.0     20.5     17.5    ST       .0     90.0    18.1   16.0000
           35.4      73.7     12.3     19.8    ST       .0     90.0    20.5    1.0000
             .0        .0       .0     26.1             .0     90.0    27.5   -8.0000
----------------------------------------------------------------------------------
  1 SUMS 142.4     448.7    136.4  /  20.5 = D.B.H.   FREQUENCY =         111.091
    PREDICTION =    90  D.B.T. =   .70  FORK   OPTIONS = 7210 UNSEEN MATERIAL
    CLASS = C66     VALUE STRATUM =  2   BASAL AREA =  2.29
    PLOT OR POINT NUMBER      7   GROWTH =     .37
**********************************************************************************
```

Figure 39.–Examples of output for both 100 foot base and 66 foot base for direct reading instruments.

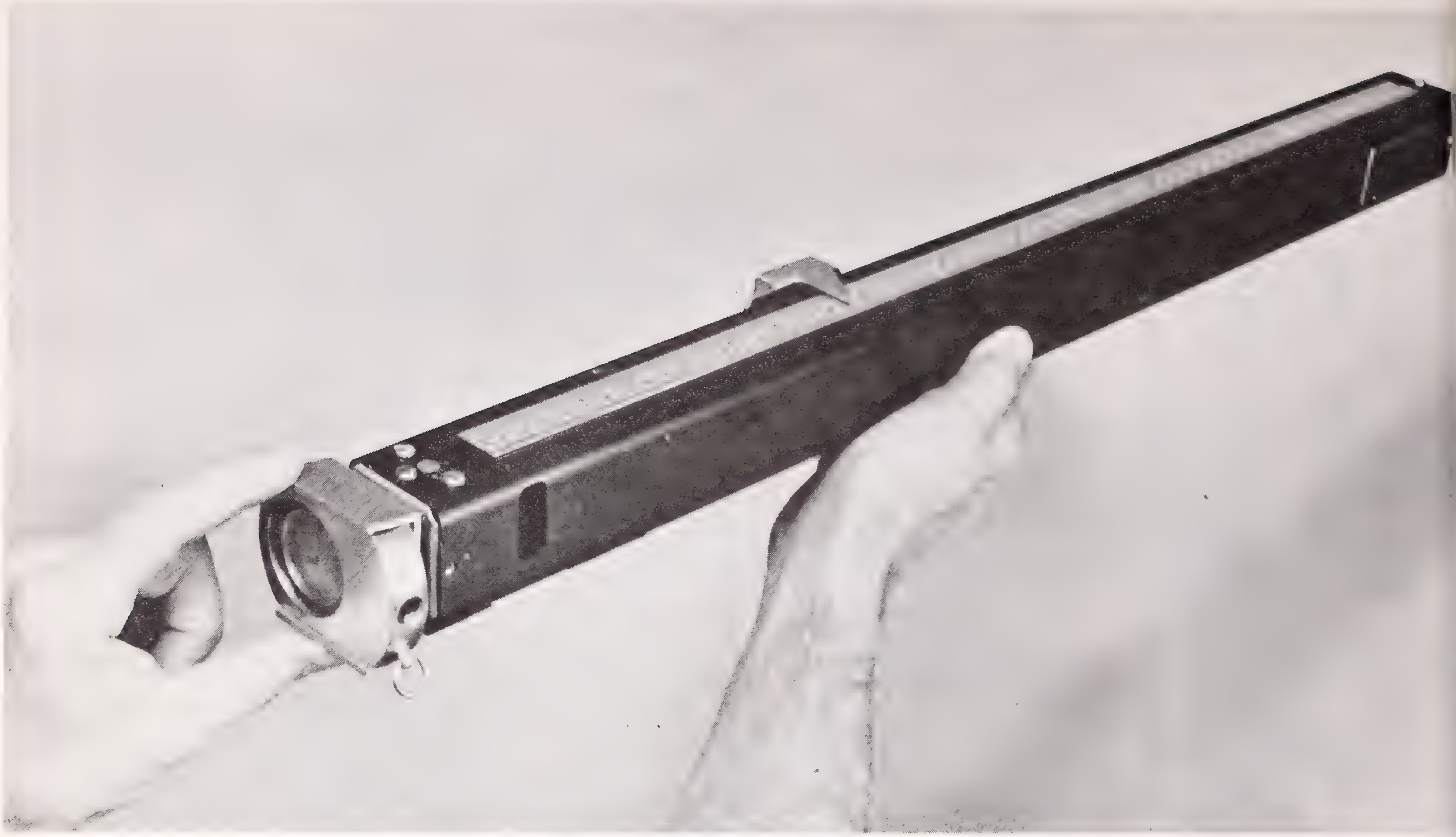


Figure 40.–Wheeler Penta-prism direct reading dendrometer with clinometer attached.

Figure 41.–Wheeler Penta-Prism in use.

Todis Dendrometer (Option 8)

Record in column 23 of tree data card. See figures 42-46.

TGRAD. – Measure slant range to tree heart (true coincidence). Read directly in meters if prism-pair range factor is 100, otherwise use appropriate factor and convert to meters. Record true range (henceforth called R) as TGRADS in *meters* and *hundredths,* omitting decimal point.

FGRADS. – If an estimate of the tree d.o.b. along the line of sight lies between 4.8 and 31.5 inches (80 cm base), remove prism-pair and measure the tree diameter directly in *centimeters* and *tenths* (false coincidence) (figures 45-46). Record d.o.b. as FGRADS in *centimeters* and *tenths,* omitting decimals.

If the estimate of the tree d.o.b. does not lie between 4.8 and 31.5 inches, go to the accompanying tables provided with the dendrometer and find a prism-pair that can fork the estimated d.o.b. and allow for the sequence of lesser diameters likely to be encountered as dendrometry progresses up the tree. Other things being equal, favor convergence *behind* the tree or *negative* convergence over convergence *between* the tree and the observer, and *large* range factors over *small.* If positive convergence is required, insert prism-pair normally, but if negative convergence is needed, swap left and right; read F false coincidence in *centimeters* and *tenths.*

If F was obtained by a prism-pair with range factor 100, record FGRADS in *centimeters* and *tenths,* omitting decimal point, as the absolute value (R – F) with positive convergence, or as (R + F) with negative convergence.

If F was obtained by prism-pair with range factor (K), record FGRADS in centimeters and tenths, omitting the decimal point, as the absolute value (100/K) * (R – F) with positive convergence, or as (100/K) * (R + F) with negative convergence.

SINELV. – Record the elevation angle in degrees and tenths as SINELV with an explicit decimal point and with depression angles preceeded by a minus sign.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S Tr. (10)	* = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
2	902	2	*	TODI	18.0	8	2		0	.4	.6		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	8

Dendrometry Data

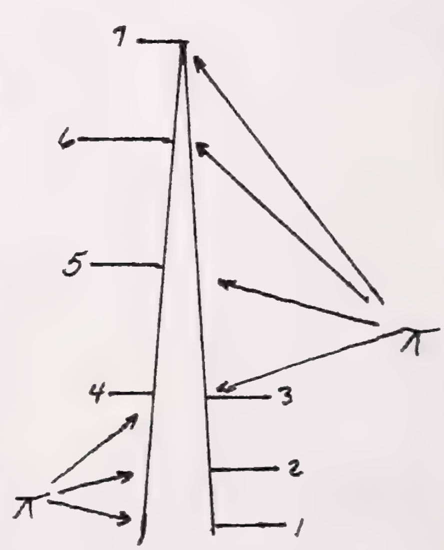
TREE NO. (1–4)	J (5)	T GRADS	F GRADS	SINELV	GR	72
2	1	12: –999	16: 210	20: 4.0	25: S T	
		27:	31: 180	35: 8.0	40: S T	
		42: 3069	46: 432	50: –6.8	55: S T	
		57:	61:	65:	70:	+
	2	12: 4572	16: 432	20: 0.0	25: T W	
		27: 4700	31: 356	35: 13.5	40: T W	
		42: 4819	46: 305	50: 19.2	55: T W	
		57: –999	61: –999	65: 33.3	70: T W	*
	3	12:	16:	20:	25:	
		27:	31:	35:	40:	
		42:	46:	50:	55:	
		57:	61:	65:	70:	
	4	12:	16:	20:	25:	
		27:	31:	35:	40:	
		42:	46:	50:	55:	
		57:	61:	65:	70:	

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)
37	8

LEAN deg.

Sketch tree below



For unseen material, total tree ht. ______ unseen merch. length ______ rate of taper ______

Dendrometer set up: bearing ______ distance ______

2–78 CC

Figure 42.–Example of Todis Dendrometer recordings, where instrument was moved to measure the upper portion of tree.

```
DENDROMETRY EXAMPLES AND OPTIONS                                 TEST  PAGE   7
CRC 8-04-80                                      2    400.  160     15467 123020
                          DETAILED LOG AND/OR TREE REPORT
================================================================================
TREE/  VOLUME  / SURFACE / LENGTH /  DIB    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /   FT.  /  IN.    /CODE/  FT./ TGRADS  FGRADS   SINELV
================================================================================
           11.2      70.0     46.1       .1   TW      .0  -99.9  -99.9   33.3000
           13.5      52.1     16.0     11.5   TW   158.1  481.9   30.5   19.2000
           42.8     139.0     36.0     13.4   TW   154.2  470.0   35.6   13.5000
             .0        .0       .0     16.1   TW   150.0  457.2   43.2     .0000
           12.0      34.7      8.0     16.1   ST   100.7  306.9   43.2   -6.8000
            7.3      19.2      4.0     17.0   ST      .0     .0   18.0    8.0000
             .0        .0       .0     19.6   ST      .0  -99.9   21.0    4.0000
--------------------------------------------------------------------------------
  2 SUMS  86.8     314.9    110.1  /  18.0 = D.B.H.    FREQUENCY =        144.093
    PREDICTION =    90  D.B.T. =  1.00  FORK   OPTIONS = 8210 UNSEEN MATERIAL
    CLASS = TODI    VALUE STRATUM =  2   BASAL AREA =  1.77
    PLOT OR POINT NUMBER      6   GROWTH =     .37
********************************************************************************
```

Figure 43.–Example of printout for the Todis dendrometer.

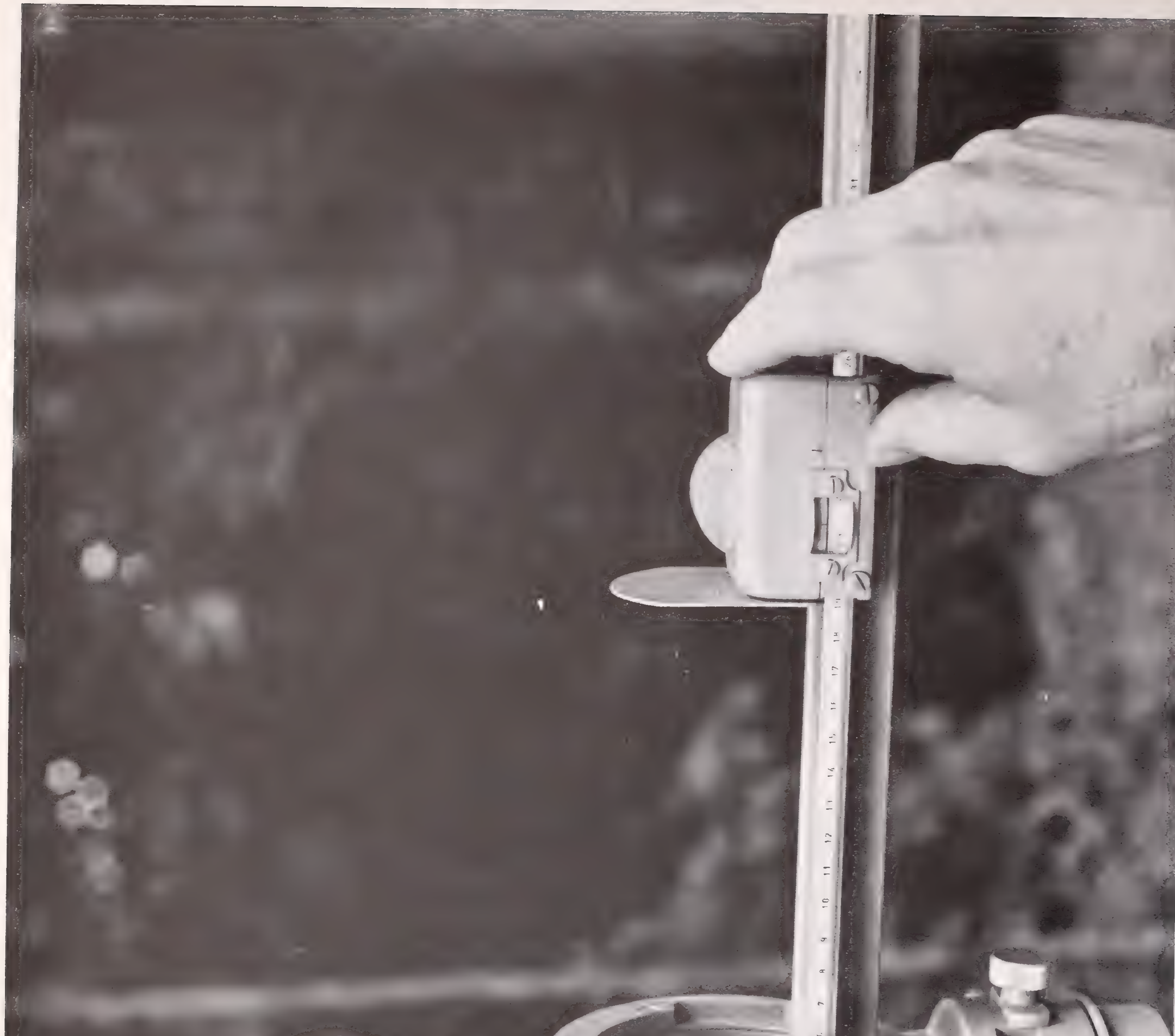


Figure 44.–Todis dendrometer in use.

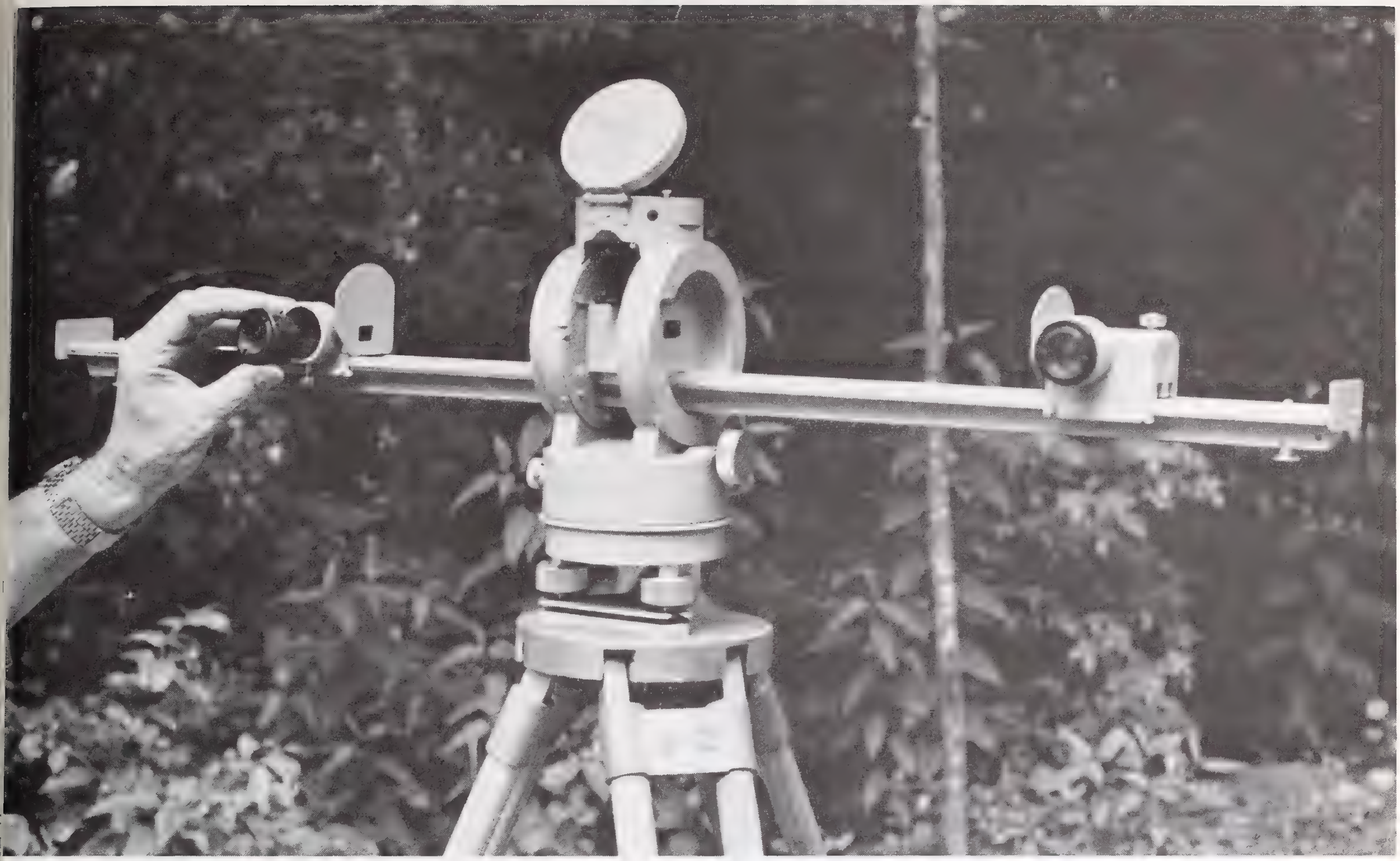


Figure 45.–Todis dendrometer – changing one of the prism-pair.

Figure 46.–Todis dendrometer – removing one of the prisms.

Tele-Relaskop (Option 9)

Record in column 23 of tree data card. See figure 48. The visible scale you see through the Tele-Relaskop eyehole is shown in figure 47. The upper rim of the scale picture is the measuring edge, along which all readings and measurements must be made. The width measure includes four tacheometer units (4TU); on figure 47 these are marked by brackets. One TU has a distance factor of Df=100 horizontal distance: width = 100:1.

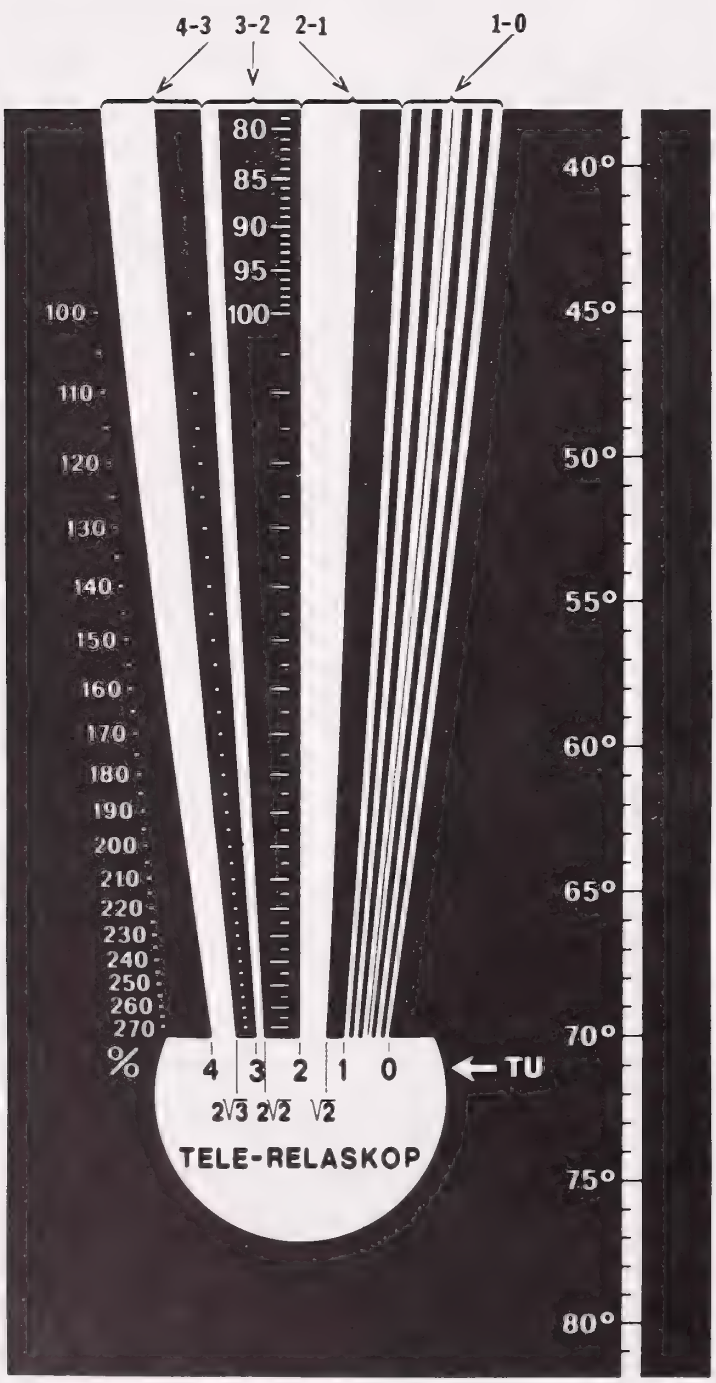


Figure 47.–The Four Tachymeter Units.

The four TU ranges on the scale key are marked as follows: from left to right, 4-3, 3-2, 2-1, each is divided from left to right into black and white bands; in pairs, these form a TU. The 1-0 range is divided into 10 small bands to form tenths of a TU.

Horizontal Base Ruler

The horizontal base ruler (figure 49) provides the value of each TU, depending on the distance. The rule, which is 120 cm in length, is placed beside the tree at d.b.h. as shown in figure 51. Use as many full TUs as possible for better accuracy. In figure 51, all four TUs gave a reading of 56.5 cm; therefore, one TU is 56.5 ÷ 4 =14.12 cm. This value is called the Base Reading.

If the Base Rule is not used, this value may be calculated from the actual measurement. The relationship of the scale is 100 to 1; therefore, if you were back a distance of 100 meters, the TU value would be 100 cm or 1 meter. Obviously, if you were back only 14.12 meters (or 46.3 feet) the TU value would be 14.12 cm (or 5.56 inches) as was determined in the example above. Observations must be taken at 90 degrees to the lean because all calculations are based on the horizontal distance to the tree. The computer output is shown in figure 52 and the instrument in use is shown in figure 50.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★= (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1	481	1	*	TELA	26.6	9	2	1	0	1.3	1.1		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	9

Dendrometry Data

TREE NO. (1) J (5)

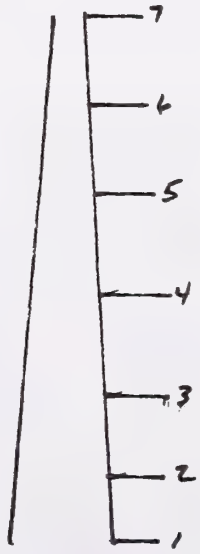
Cols. 1-4, 73-80 are in every card.

TREE NO.	J	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	72
1	1	12	-999	16	32.4	20	3.5	25		
		27		31	26.6	35	5.0	40	5T	
		42	74.1	46	3.7	50	9.0	55	5T	
		57	74.1	61	3.0	65	18.0	70	5T	
	2	12	74.1	16	2.5	20	30.0	25	5T	
		27	74.1	31	2.2	35	47.0	40	5T	
		42	74.1	46	1.9	50	55.0	55	5T	
		57		61		65		70		*
	3	12		16		20		25		
		27		31		35		40		
		42		46		50		55		
		57		61		65		70		
	4	12		16		20		25		
		27		31		35		40		
		42		46		50		55		
		57		61		65		70		

GROWTH (73–76)	CFI POINT NO. (77–80)
.8	9

LEAN deg.

Sketch tree below



For unseen material, total tree ht. ______ unseen merch. length ______ rate of taper ______

Dendrometer set up: bearing ______ distance ______

2–78 CC

48

Figure 52.–Example of Tele-Relaskop dendrometer recordings of a normal tree, first two measurements are physical.

Figure 49.–Horizontal Base Ruler, 120 cm long, used to determine the "TU" distance and diameter factor.

Figure 50.–Tele-Relaskop dendrometer in use.

Tele-Relaskop Measurements

The tree must be measured from the left side so that the left, upper corner of the white bar coincides with the left edge of the tree, and the right side of the tree falls into the tenth field. Count first the full TUs to the left of "1", then the remainder in the tenth bars, or the estimated fractions to the right of "1". For the example shown in figure 48, the correct reading is 2.75 TUs.

TGRADS. – Determine the value of one Tacheometer Unit (TU) in centimeters as read from the range scale. Record centimeters and tenths as shown in figure 51. (format F4.1)

FGRADS. – The number of Tacheometer Units (TU) that relate to the tree diameter recorded in TU and tenths (format F4.1).

SINELV. – Percent height reading recorded as percent and tenths (format F5.1).

Note: The program will convert the metric units to feet and inches or, with special options, will produce metric output.

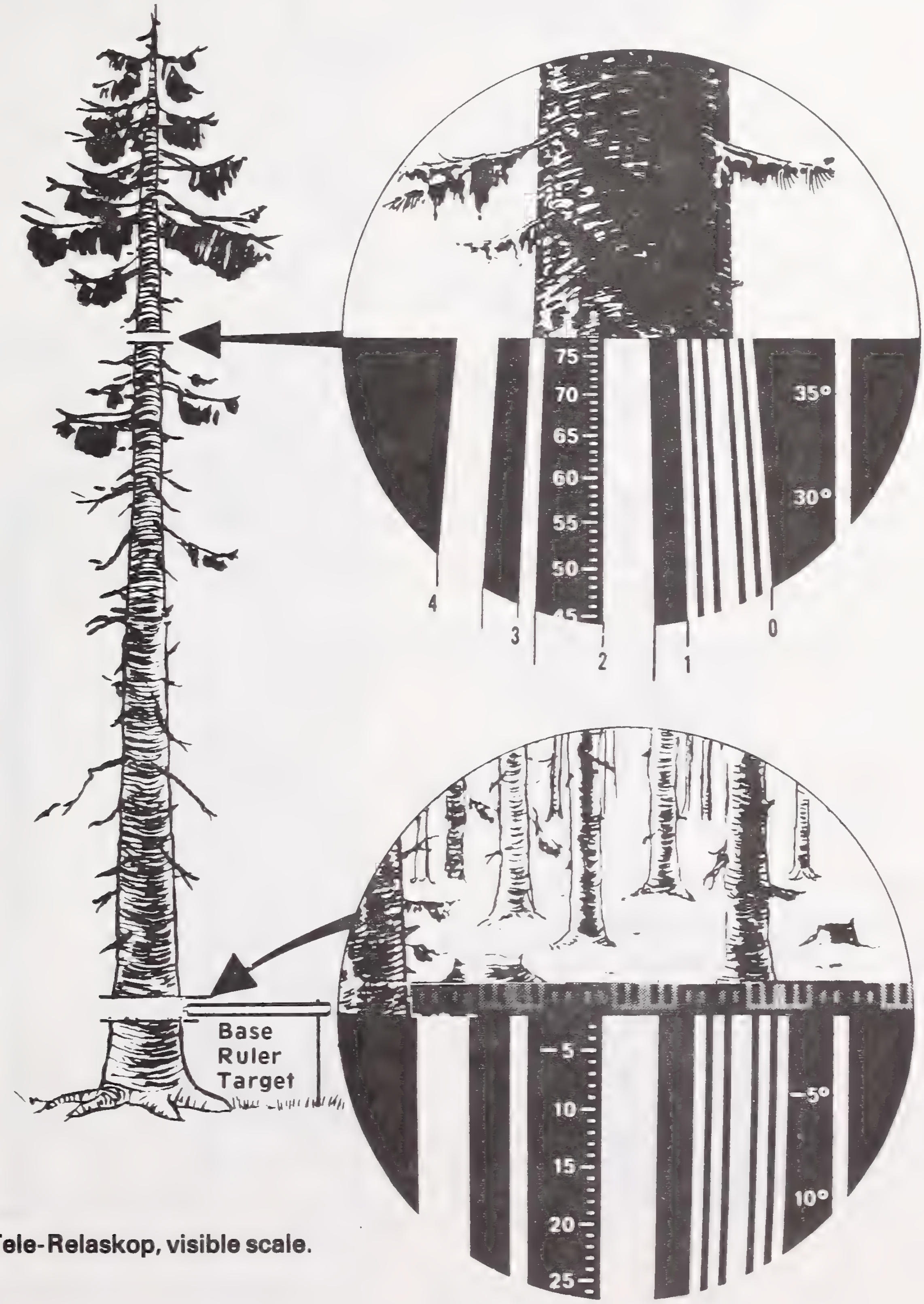


Figure 51.–Tele-Relaskop, visible scale.

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DENDROMETRY EXAMPLES AND OPTIONS                                        TEST  PAGE   8
CRC 8-04-80                                          2     400.  160      15467 123020
                           DETAILED LOG AND/OR TREE REPORT
=====================================================================================
TREE/  VOLUME  / SURFACE / LENGTH /  DIB   / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /   FT.  /  IN.   /CODE/  FT./ TGRADS  FGRADS    SINELV
=====================================================================================
            30.8        74.9       14.5       19.3   ST    94.3     26.0   2.05   47.0000
            23.7        55.2       10.2       20.2   ST    89.1     26.0   2.15   30.0000
            19.7        43.6        7.7       21.0   ST    86.7     26.0   2.25   18.0000
            14.6        30.3        5.0       22.3   ST    85.6     26.0   2.40    9.0000
            13.1        24.0        3.5       24.0   ST      .0       .0  26.60    5.0000
              .0          .0         .0       28.4           .0    -99.9  32.40    3.5000
-------------------------------------------------------------------------------------
   1 SUMS 102.0      228.1      40.9  /  26.6 = D.B.H.    FREQUENCY =          134.153
     PREDICTION =    48  D.B.T. =  2.60  FORK    OPTIONS = 9210 UNSEEN MATERIAL
     CLASS = TELR    VALUE STRATUM =  1    BASAL AREA =  3.86
     PLOT OR POINT NUMBER      9    GROWTH =     .80
*************************************************************************************
```

Figure 52.–Example of output for the Tele-Relaskop dendrometer.

SPECIAL DENDROMETRY PROCEDURES

Many trees, because of unusual characteristics or other problems, require the use of special techniques, the most common of which are outlined below. Whenever there are likely to be questions arising during data processing or in remeasurement of permanent sample trees, the tree should be diagrammed in the space provided on the right side of the field sheet.

When using any of the instruments, it is advisable to hand calculate a few measurements to make sure the instrument is being read properly. The Barr and Stroud dendrometer (model FP-15) has a convenient slide rule scale described by Mesavage (1968), which can be used as a quick field check. For all of the other instruments, hand calculations can be made in the field.

Direct measurement at stump and d.b.h. – It is usually more convenient to measure diameters at the stump and d.b.h. directly, because the stump is often obscured by brush or grass and the measurement at d.b.h. has already been obtained, in many cases. Code the first TGRADS as –999 to indicate direct measurement; record the stump diameter in inches and tenths. Enter an explicit decimal point (S.I. units in centimeters and tenths) in FGRADS, and record the distance from the stump to d.b.h. in feet and tenths, with explicit decimal point (S.I. units in meters and tenths) recorded under SINELV. No grade is needed from the stump measurement, but will be ignored if entered. On the second line, TGRADS is left blank, and d.b.h. is recorded under FGRADS. Record the distance upwards to the first dendrometer measurement under SINELV. A stick of known length may be affixed to the trunk of the tree with its bottom at the d.b.h. mark to provide the distance and an aiming point for the dendrometer. Enter an appropriate log grade (GR) on this line for the section between the two diameter measurements.

Unseen merchantable material in top. – One of the most common problems occurs when a measurement cannot be obtained at the merchantable top. If this is the case, use the following procedures, listed in decreasing order of accuracy:

1. If a reading can be obtained somewhere above the merchantable top, take a reading there. Determine the merchantable top of the tree by interpolation.
2. Take a dendrometer reading on the top of the tree. Code TGRADS and FGRADS as –999's and record the SINELV of the top. Determine the merchantable top of the tree by interpolation.
3. To obtain at least four uninterrupted dendrometer readings below the merchantable top, enter code 1 in the unseen material option in column 25 of tree data card and –999 in the FGRADS column following the last dendrometer measurement. The computer will project to the specified top diameter based on the taper and form of the tree. However, enter your best estimate of the total tree height, unseen material length, or rate of taper on the dendrometry data sheet in the remarks column as a check against this projection. Also, avoid taking the last dendrometer readings immediately below a whorl of limbs, as this often produces an abnormally low or even negative rate of taper.
4. If you are unable to obtain 4 uninterrupted measurements, enter a "2" in column 25 of the tree data card for the unseen material option, and enter the estimated unseen merchantable length and rate of taper in the UML and UDT fields, respectively.

Undefined merchantable top. – If the tree does not have a well-defined cutoff point and you cannot tell the point where it reaches the minimum merchantable diameter, take at least one set of readings above the merchantable top. Specify one of the interpolation options (column 26) to find the merchantable top. Of course, projection of measurements below the top may also be used, but may be somewhat less accurate.

Undefined boundary between merchantability specifications. – Where the basis for merchantability of a product includes a minimum diameter, the boundary between two merchantability classes may be obscured or difficult to determine. This point may be found by interpolation during processing by specifying the appropriate interpolation codes in column 26. For example, a tree section with its base larger than the minimum top diameter for sawtimber and its top smaller than the minimum top, could be split into two sections by interpolation: a sawtimber section from the bottom to the minimum top diameter and a pulpwood section above that.

Measuring trees unsuitable for dendrometry. – Very small trees can be dendrometered, but it is usually much more convenient to measure them directly. Down trees must always be measured directly. Other types of dendrometers, such as the Wheeler pentaprism and McClure mirror calipers, or the Spiegel Relaskop may be used. They give direct readings of diameter and length.

If direct measurements are taken, the type of measurement option should be coded "2", "6", or "7". Refer to the discussion of the use of these dendrometer options.

Leaning trees.–Trees leaning up to 15 degrees from the vetical can be dendrometered with little loss of accuracy in height measurements (about 3.5 percent). More steeply leaning trees can still be dendrometered, but the lean of the tree (in degrees from vertical) should be noted on the field sheet so the vertical measurements can be corrected. Also note any sections of a tree which are more than 15 degrees from the vertical and show the lean in degrees on the field sheet for later correction. Enter an estimated length of segments leaning more than 60 degrees. Very steeply leaning trees can often be climbed and directly measured. Leaning segments must be corrected by hand and the measurements repunched as direct readings when using all instruments except the transit dendrometer. The formula for correction is:

Corrected length = uncorrected length ÷ cosine angle of lean

Cull. – Show cull sections in otherwise sound trees by an appropriate grade code. In noncull sections which are known to be partly defective, the percentage or volume of unsound material can be entered in columns 73-76 of the tree data card (figure 5). The proper options must also be made on control card 10, columns 57 and 58.

If volumes are desired for cull or other unmerchantable trees, they should be selected for dendrometry and measured in the same manner as other trees. These trees should be processed, however, as a separate stratum. If volumes are not needed, but number of trees and basal area are desired, exclude these trees from the 3-P sample, classes as sure-to-be-measured, and put an asterisk (*) in the TERM column of the tree data card.

Forked trees. – Dendrometer measurements are taken up the stem of the tree until a fork occurs. See figure 53. A plus (+) sign is then entered in the TERM field to indicate that a new set of measurements begins on the next card. Then measure each fork and terminate the record with a plus sign except, of course, for the last, which should be terminated by an asterisk (*). The tallest fork should be recorded last. Dendrometer readings should be taken so that the volume in the crotch is not included twice (figure 53). Any fork for which a computer projection to a merchantable top is desired must have at least four sets of measurements. (See *Unseen merchantable material in top, method 3.*)

Moving the dendrometer. – Occasionally it is necessary to move the dendrometer for a better view of the tree. The instrument may be moved either up or down hill. The card containing the last measurement before the move should have a plus (+) sign entered in the TERM field. The dendrometer may then be moved to a new position. Take a new set of dendrometer readings at the last measured point to establish a new base. Measurements are then continued up the tree. Advantage may be taken of any truncations due to forks to move the dendrometer. In other words, the dendrometer may be moved whenever a plus sign has been entered in TERM and a new set of readings is about to begin.

When using the Barr and Stroud and Todis

dendrometers, a new distance need not be determined, as the instrument has a built-in range finder. However, all other dendrometers require the input of the new distance to calculate height and, in some cases, diameter.

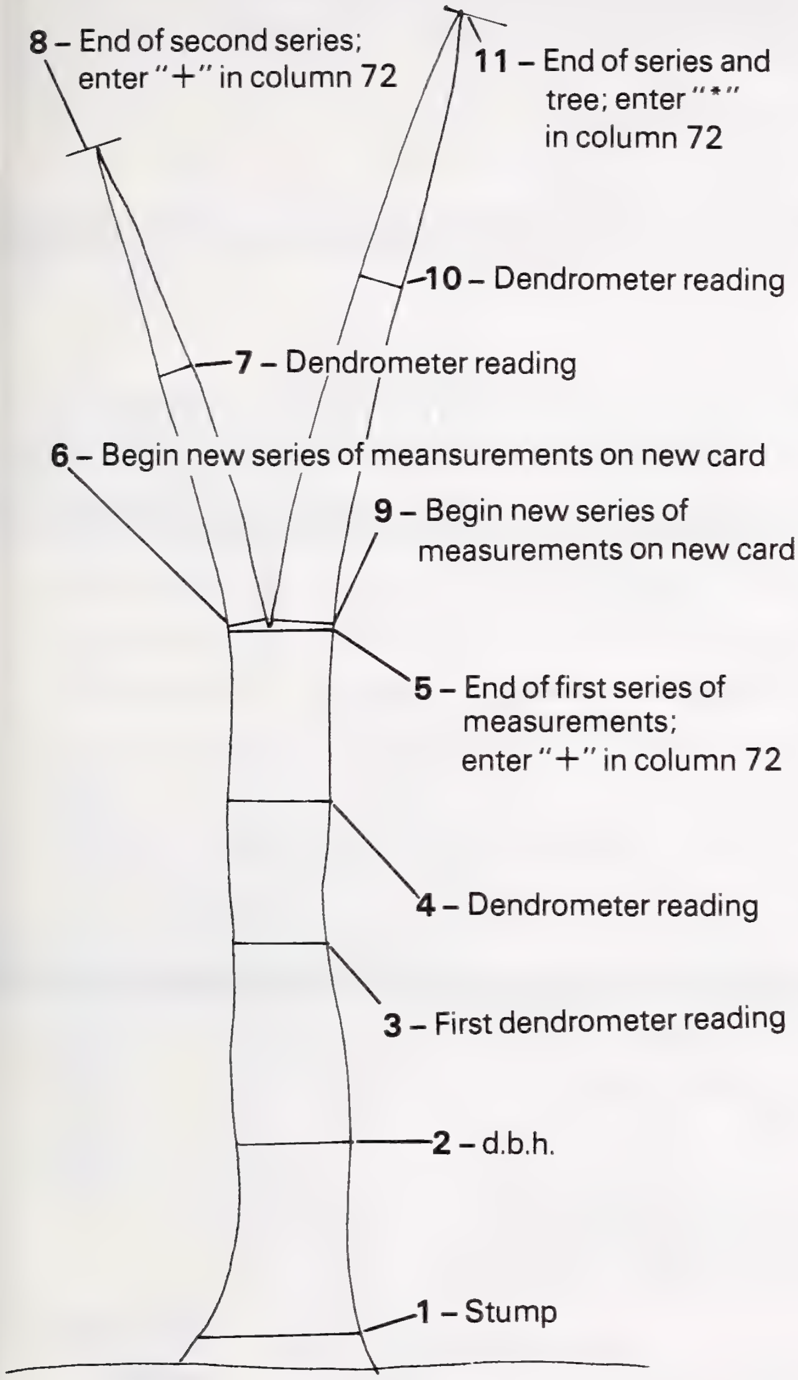

Figure 53.–Dendrometry of forked tree

Remeasurement of dendrometry. – The dendrometer should be of the same type previously used and should be placed in approximately the same position as the last time, using the recorded bearing and distance from the tree. If the stump and breast height diameters were measured directly the last time, they should also be measured directly this time. Aim the dendrometer at the point where the first set of readings is to be taken, and record as before. However, it is not practical or necessary to find the exact point at which the dendrometer was set up the last time or the exact point on the tree bole, although it is helpful when comparing one inventory with another.

Take readings at all the points where readings were taken the last time by identifying each previous SINELV reading on the instrument being used. You should then be looking at approximately the same point as the last time. It may be necessary to move the instrument slightly up or down the tree to obtain a reading because of a slightly different instrument location or leaves, limbs, or moss which are now in the way. The new TGRADS, FGRADS, and SINELV readings are recorded and cross-checked with the readings last time. You may need to take additional dendrometer readings because of the growth in height of the tree or because of changes in merchantability standards from the previous measurement.

The tree's frequency calculated by the program at the time of the first measurement should be recorded in XTRA.

Ingrowth at remeasurement. – At the time that the permanent plot or point is installed for a CFI, information is gathered from the included submerchantable trees to provide ingrowth information for the remeasurement update. Submerchantable trees are usually those that are less than pulpwood size or some similar product that is considered too small to measure in detail at this time, but will grow into the minimum merchantability class before the next update.

The submerchantable trees are recorded using the same format as discussed earlier under *Tree Data*. Enter an equal (=) sign in column 11 and an asterisk (*) in column 72. When this is done, only a frequency factor is calculated for this tree and printed in the DETAILED LOG AND/OR TREE REPORT. When the inventory is updated and the tree has grown into minimum merchantability, it is measured like any other sample tree with the frequency factor entered in XTRA so as to represent its proportionate share of the volume in the overall inventory.

CONTROL CARDS FOR STX

The program requires that 10 control cards (CC) precede the data, even if one or more of the cards are blank. It is through the use of these control cards that the user is provided the flexibility of several sampling designs, data input, program output, statistics for multi-stage sampling, board foot volumes, product interpolation and growth. The fields of the 10 control cards along with the format and variables occupying these fields follow. See figures 54 to 63.

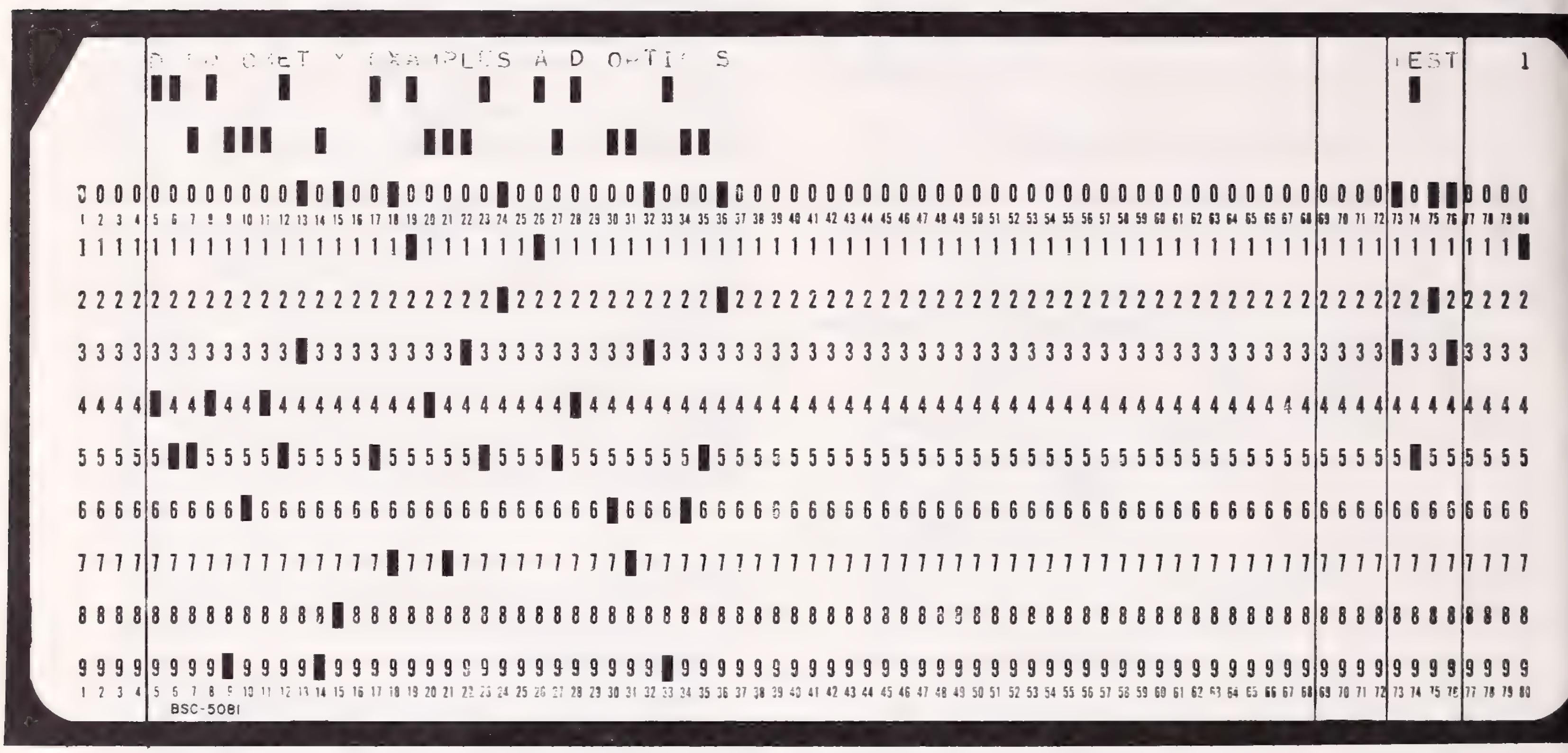

Figure 54.–STXMOD Control Card 1.

CONTROL CARDS FOR STXMOD

Card column	Entry on tally sheet	Variable name	Statement format
1-4	Blank	KREENO	I4
5-68	Name of sale or inventory job	ALFATH	16A4
69-72	Blank		4X
73-76	Job identifier	CDID	A4
77-80	Control card number	(not read)	

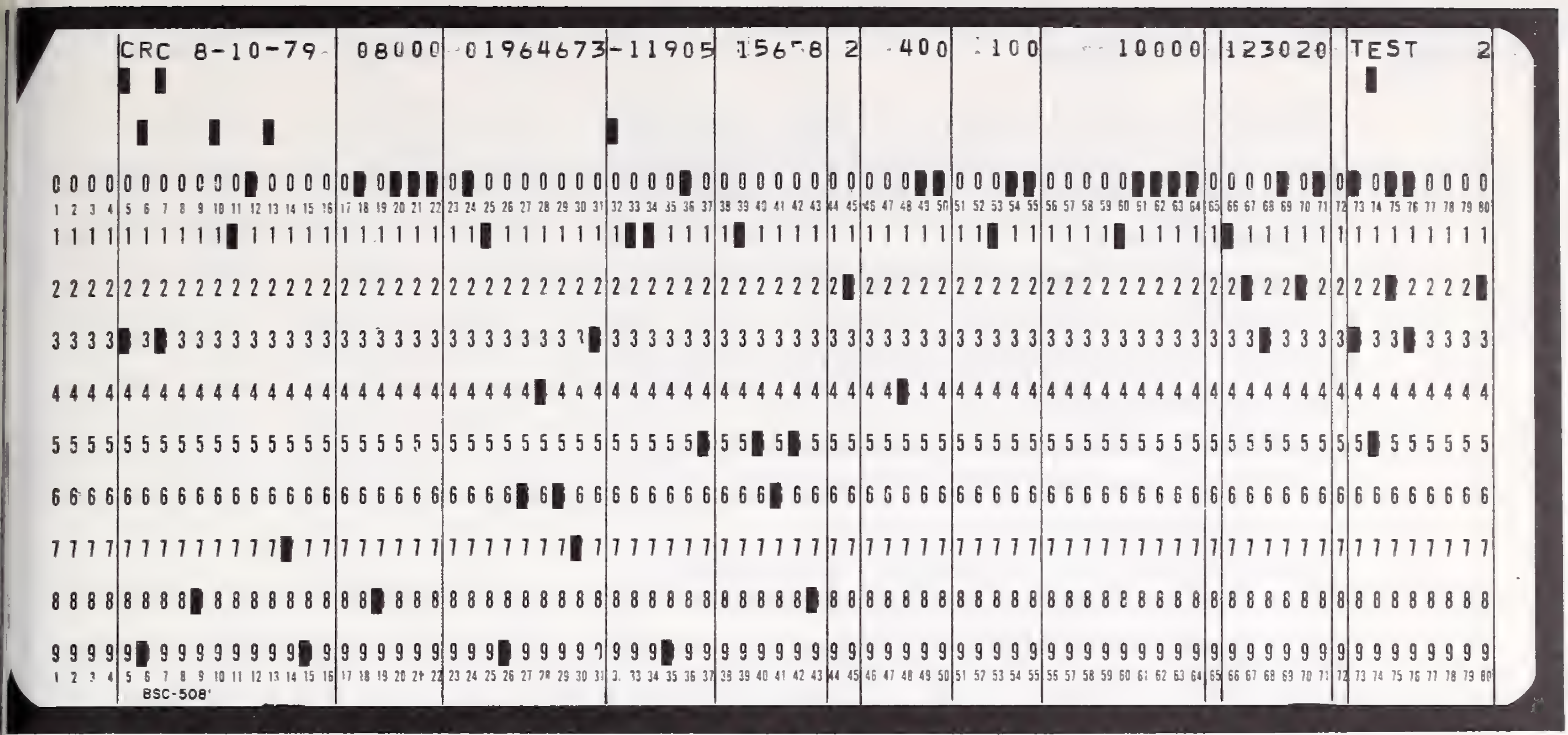

Figure 55.–STXMOD Control Card 2.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-4	Blank		4X
5-16	Short identifier	ADALFA	3A4
17-43	Blank (see section on Barr and Stroud dendrometer)		
44-45	Largest stratum number	NSTR	I2
46-50	Value of KZ is used to generate 3-P random numbers list	PRBS	F5.0
51-55	Value of K is used to generate 3-P random numbers list	KQ	I5
56-64	Expansion factor for cruise inventory:	IQ	I9

a. 1,0, or blank for pure 3-P sample (no point sampling).

b. –1 for multistage designs where XTRA, XTRB, and/or CC 6 is used.

c. For point sampling design:

$$\frac{\text{Acres}}{\text{Number of plots}} \text{ *BAF*100 or}$$

$$\frac{\text{Hectares}}{\text{Number of plots}} \text{ *Metric BAF*1000}$$

d. When IQ is negative, the minus sign tells the program to go to XTRA and/or CC 6 to be picked up as a multiplier, *and to pick up XTRB as a divisor by tree.* If nothing is entered in either CC 6, XTRA and/or XTRB, 1 is assumed.

Card column	Entry on Tally Sheet	Variable name	Statement format
65	Blank if input is in U.S. units; + if input is metric units.	JZ	A1
66	0 or 1) input cards are punched for all trees including predicted (KPI) trees. CC3, CC4, CC7, and CC8 must be left blank. 2) input cards are punched for sample trees only – complete CC3, CC4, CC7, and CC8. 3) like 1, but adds frequency balancing, as discussed by Grosenbaugh (1974) 4) like 2, but adds frequency balancing, op. cit.	LS1	I1
67	0 or 1) processing will stop after the program has calculated and printed the preliminary report. 2) processing will continue if no fatal errors occur.	LS2	I1
68	0 or 1) no individual tree detail will be printed. 2) individual tree detail will be printed. 3) individual tree and tree segment detail will be printed.	LS3	I1
69	0 or 1) no detail cards will be punched as part of the output. 2) tree detail cards will be punched as part of the output.	LS4	I1
70	0 or 1) no log and tree detail will be written on tape for later grade yield and realization processing. 2) log and tree detail will be written on tape and will be processed if no fatal errors have occurred, but subtotals only will be printed. 3) same as 2 above, but prints sorted individual log detail before class-grade subtotal. 4) same as 2 above, but prints within tree sorted subtotals before class-grade subtotals. 5) like 2 above, but prints within tree sorted subtotals before full sorted log detail. 6) prints within tree sorted subtotals, but omits full log sorts.	LS5	I1
71	0) no further processing. 1-9) not more than this indicated number of sets of conversion co-efficients will be searched to convert subtotals to product out-turn and realization values.	LS6	I1
72	Blank		
73-76	Blank or job identifier	(not read)	
77-80	Control card number	(not read)	

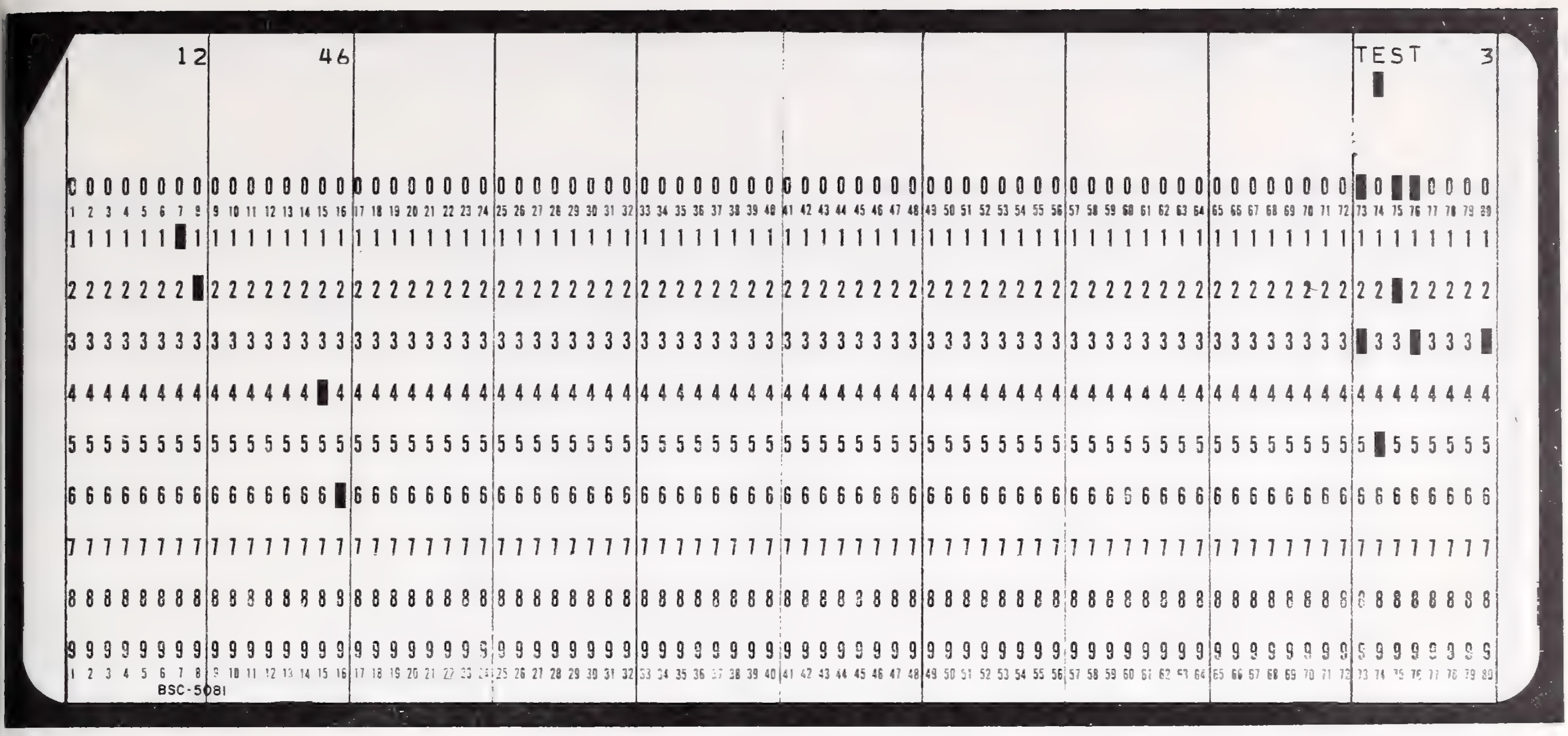

Figure 56.–STXMOD Control Card 3. Enter the total number of trees in each stratum when the job option LS1 equals 2 or 4. This card will be blank when LS1 equals 1 or 3.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. Show the total tree count in each stratum.	JN(I)	9I8
73-76	Blank or job identifier	(not read)	
77-80	Control card number	(not read)	

When LS1 equals 1 or 3 the computer counts the number of NN + NS + NR for each stratum and prints this value.

When LS1 equals 2 or 4 the count of $\sum^{3}$(NN+NS+NR) for each stratum must be entered by the user in the stratum field.

Where:
- NN = Pre-3P-selected trees (sure-to-be-measured)
- NS = 3P-selected trees
- NR = 3P-rejected trees

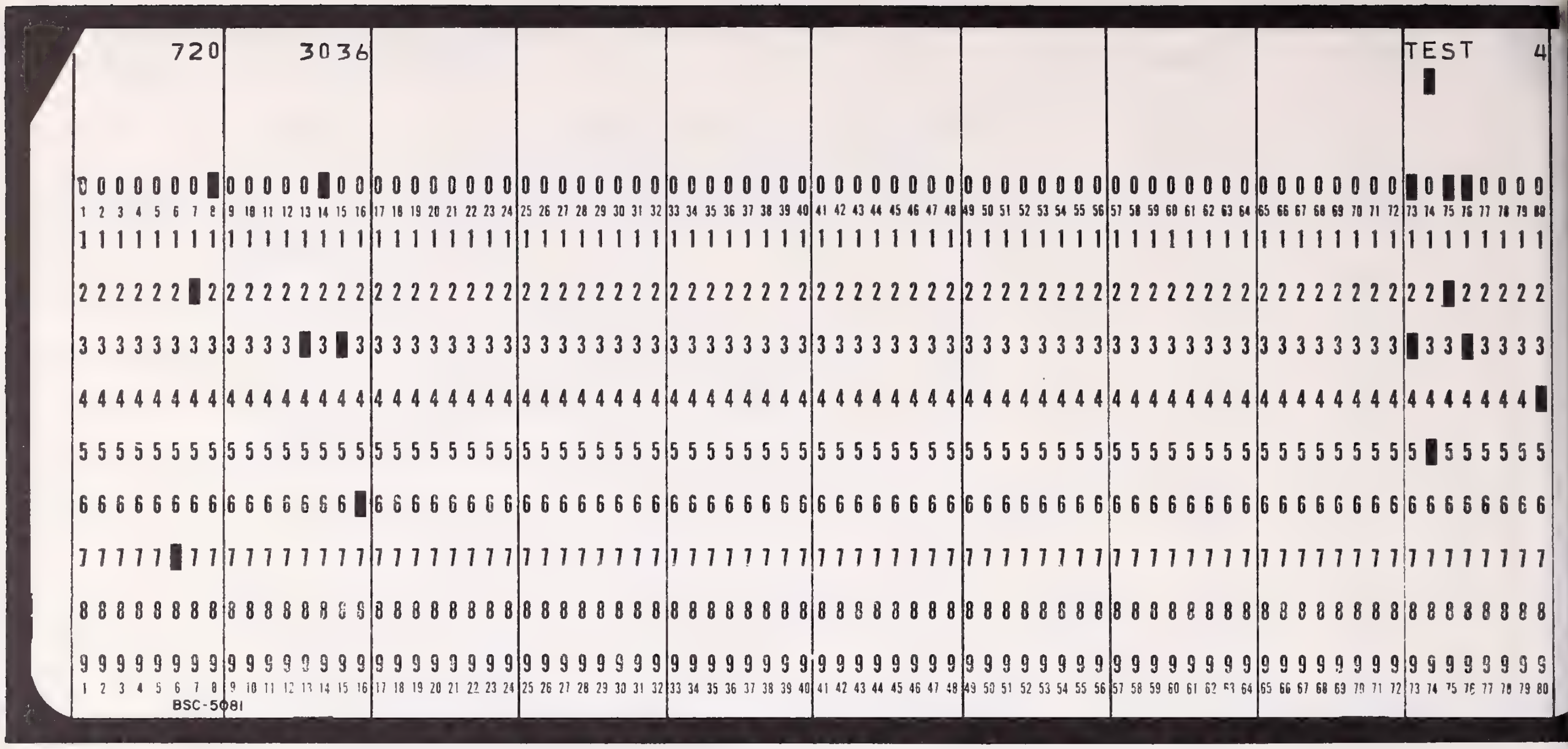

Figure 57.–STXMOD Control Card 4. – Enter the aggregate predictions for the trees in each stratum when the job option LS1 equals 2 or 4. This card will be blank when LS1 equals 1 or 3.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. Show the aggregate predictions in each stratum. This card is blank if CC2, column 66, is 1 or 3.	KP(I)	9I8
73-76	Blank or job identifier number	(not read)	
77-80	Control card number	(not read)	

When LS1 equals 1 or 3, the computer sums

$\sum^{NN} KPI + \sum^{NS} KPI + \sum^{NR} KPI$ for each stratum and prints this value.

When LS1 equals 2 or 4, the sum of

$\sum^{NN} KPI + \sum^{NS} KPI + \sum^{NR} KPI$ for each stratum must be entered by the user in the stratum field

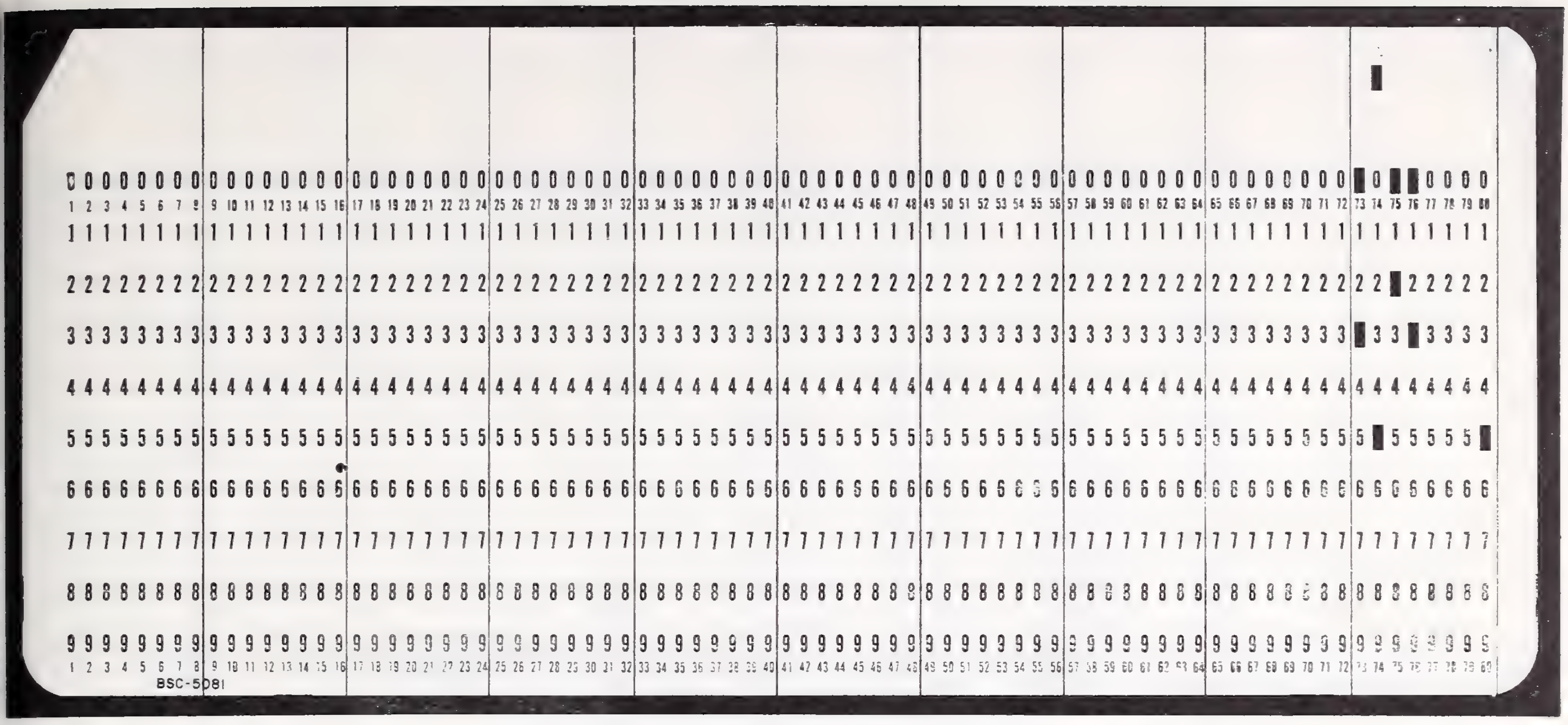

Figure 58.–STXMOD Control Card 5.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. Show the relative value within each stratum. Card is left blank unless strata differ in *value* per unit of volume.	WV(I)	9I8
73-76	Blank or job identifier.	(not read)	
77-80	Control card number	(not read)	

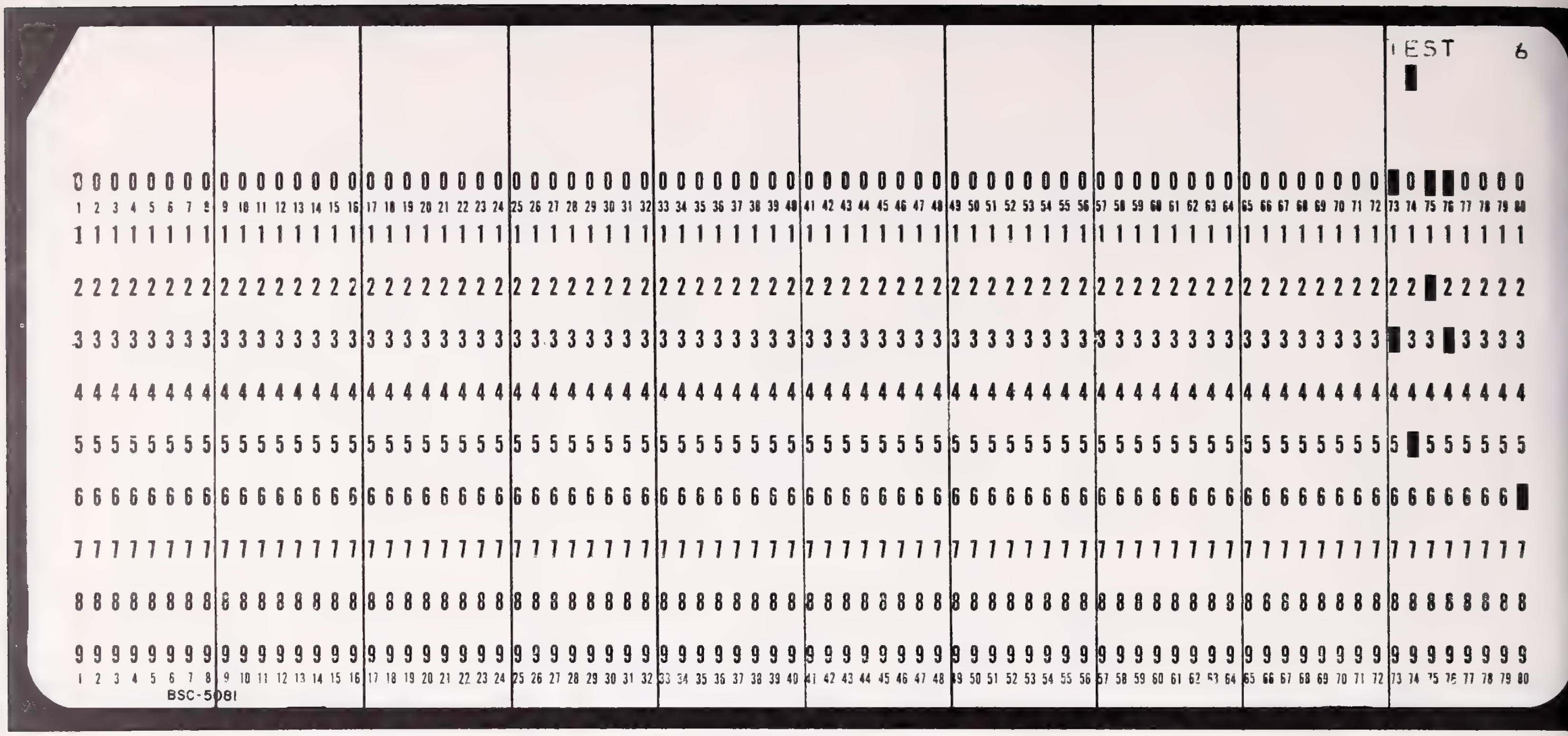

Figure 59.–STXMOD Control Card 6.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. Show the blowup or correction factor for each stratum when IQ (CC2, column 56-64) is negative. If all strata have the same blowup factor, enter in columns 1 to 8 (only) as a negative figure.	ASX12(I,9)	9F8.0
73-76	Blank or job identifier.	(not read)	
77-80	Control card number	(not read)	

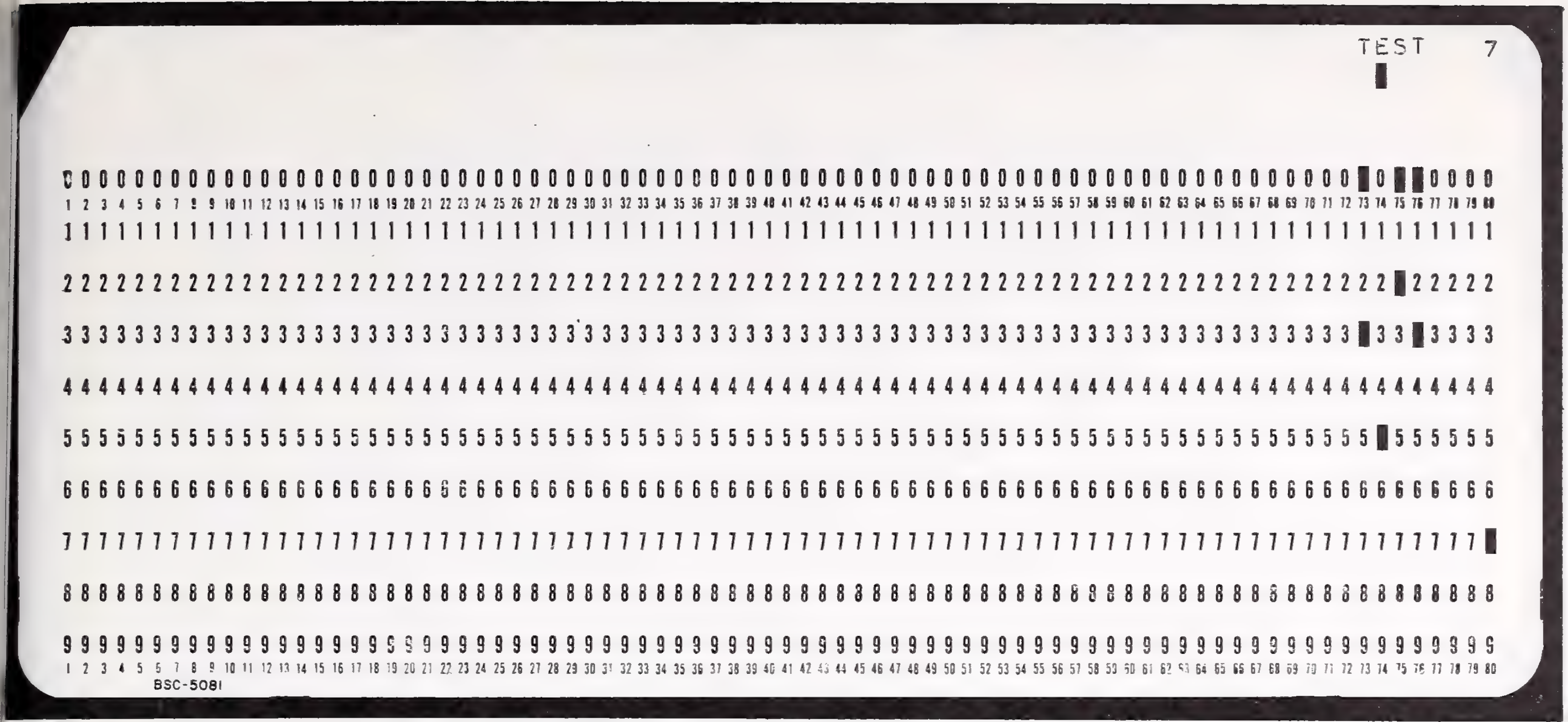

Figure 60.–STXMOD Control Card 7.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. Show the weights for each stratum (program computed when option 1 or 3 is used on CC2, column 66.)	ASX 12(I,11)	9F8.0
73-76	Blank or job identifier.	(not read)	
77-80	Control card number	(not read)	

When LS1 equals 1 or 3 the values are program computed as follows:

$$CC7 = CC6 * \left[\sum^{NN} \frac{XTRA}{XTRB*PBI} + \sum^{NS} \frac{XTRA}{XTRB*PBI} + \sum^{NR} \frac{XTRA}{XTRB*PBI} \right]$$

When LS1 equals 2 or 4, this card may be left blank for simple 3-P sampling, or enter the values that were program computed from a previous run when doing multistage sampling.

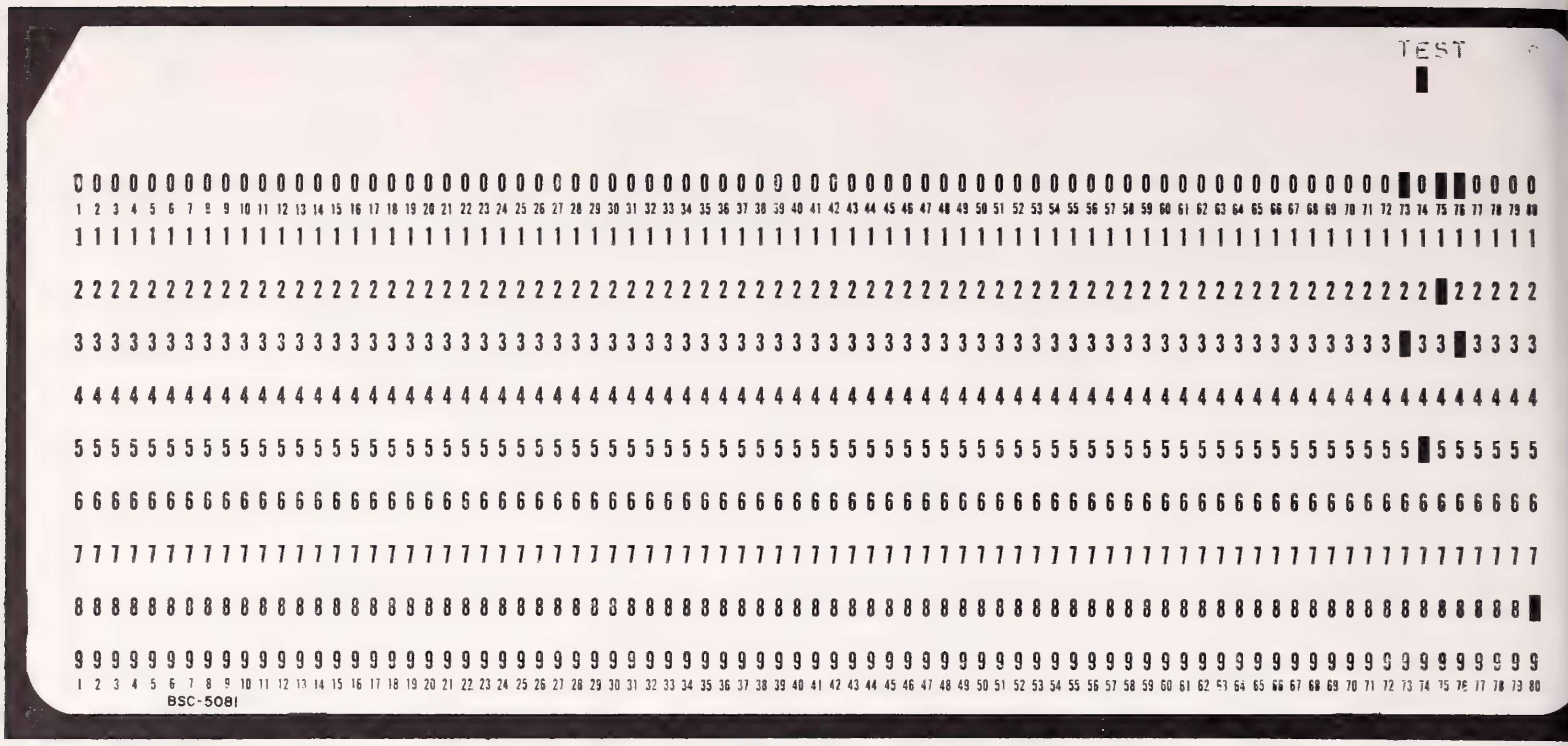

Figure 61.–STXMOD Control Card 8.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each. The same as CC4 (but weighted) if option is 2 or 4 on CC2, column 66 weights for each stratum are program computed when option is 1 or 3 on CC2, column 66. In this case, CC8 is left blank.	ASX(I,12)	9F8.0
73-76	Blank or job identifier	(not read)	
77-80	Control card number.	(not read)	

When LS1 equals 1 or 3, the values are program computed as follows:

$$CC8 = CC6 * \left[\sum^{NN} \frac{XTRA*KPI}{XTRB} + \sum^{NS} \frac{XTRA*KPI}{XTRB} + \sum^{NR} \frac{XTRA*KPI}{XTRB} \right]$$

When LS1 equals 2 or 4, the values are the same as those entered in CC4 when using simple 3-P sampling, or enter the values that were program computed from a previous run when doing multi-stage sampling.

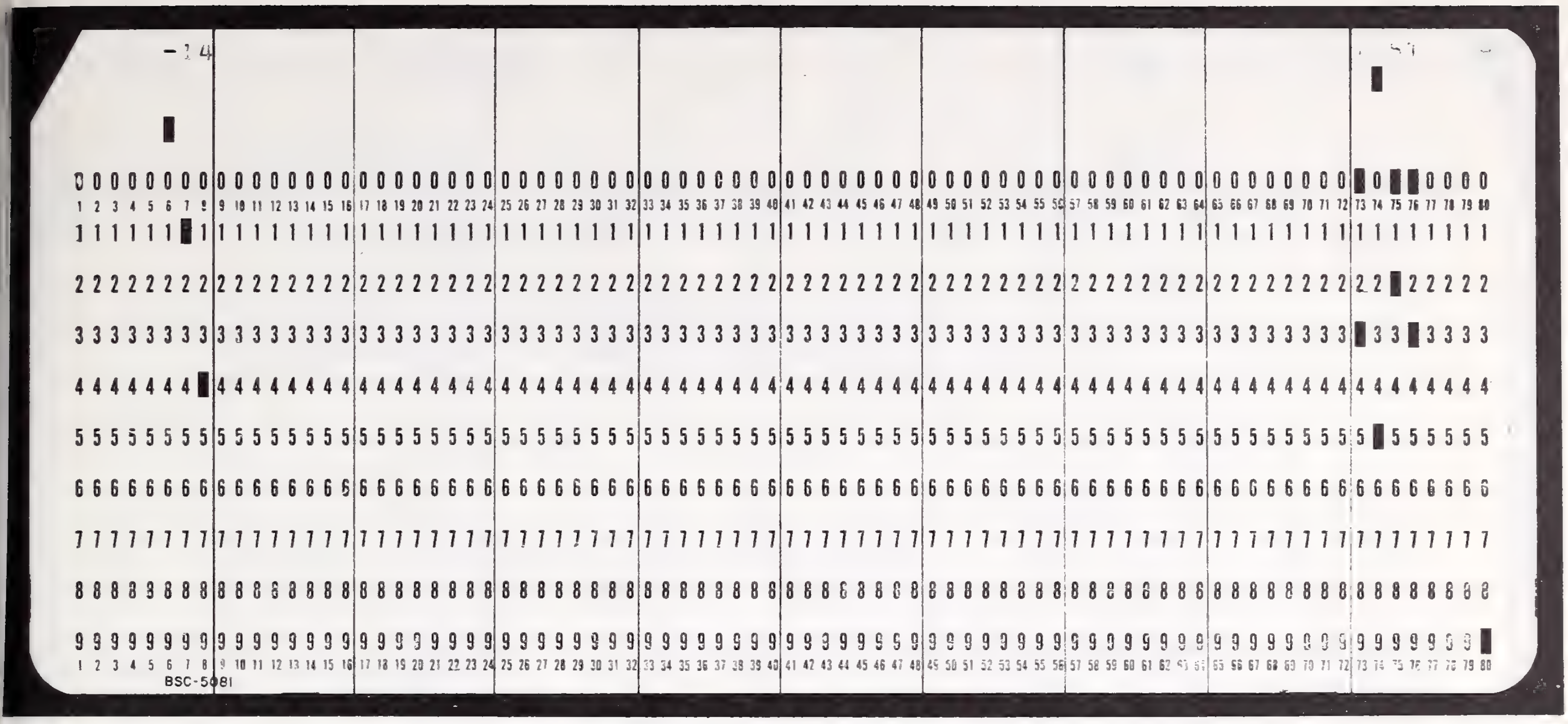

Figure 62.–STXMOD Control Card 9.

Card column	Entry on Tally Sheet	Variable name	Statement format
1-72	Use nine fields of eight columns each when first-stage statistics are desired. For multistage cruises, enter the actual number of plots as a negative figure (columns 1-8) if the first stage is not stratified. If the first stage is stratified, enter the number of plots per stratum as a positive figure.	IPLOTS(I)	9F8.0
73-76	Blank or job identifier.	(not read)	
77-80	Control card number.	(not read)	

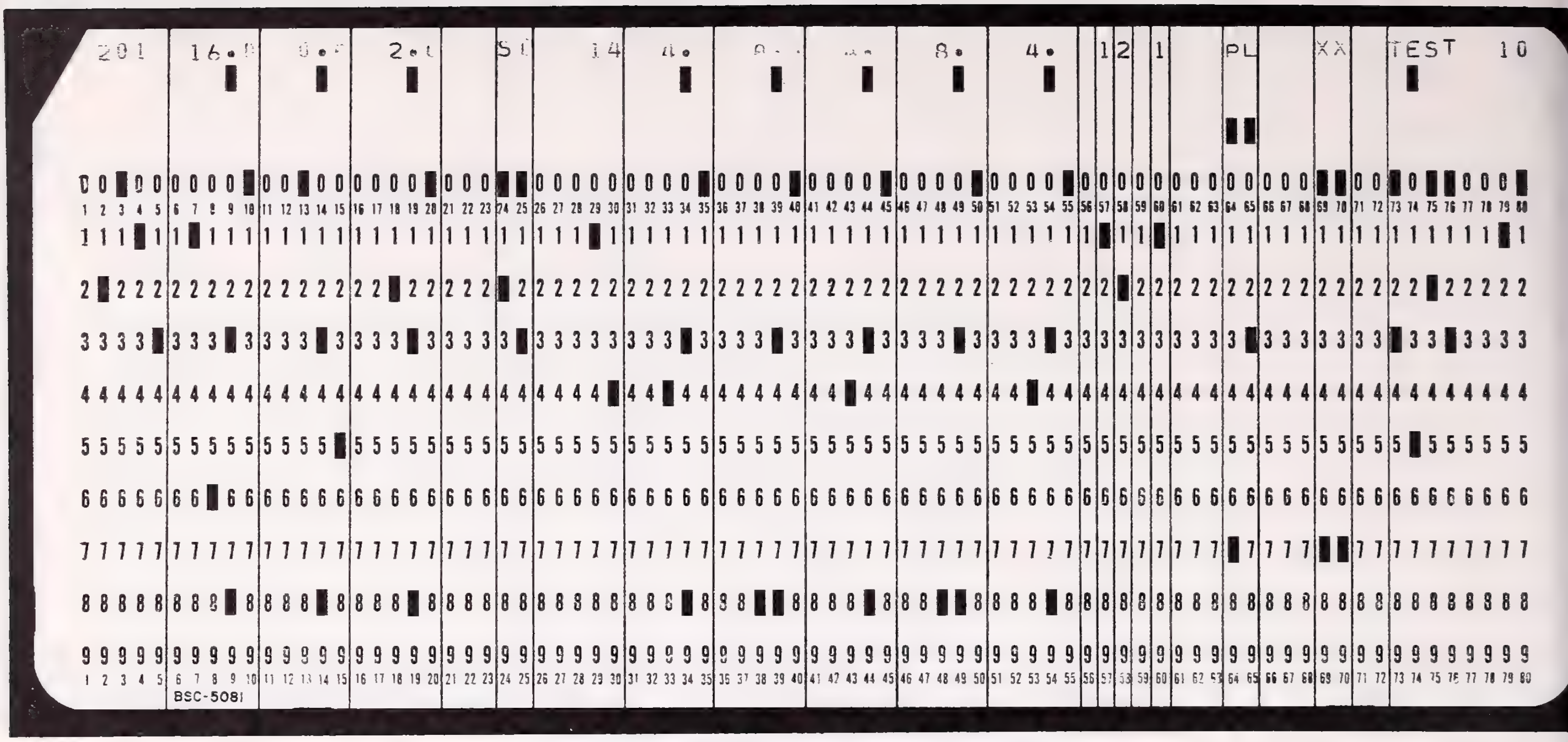

Figure 63.–STXMOD Control Card 10.

Card column	Entry on Tally Sheet	Variable name	Statement format
1	Bark deduction: 0, blank. deduct bark, either input or program computed. 1, no bark deductions will be made.	NOBARK	I1
2	Write board foot reports: 0, blank. None. 1, log and tree report. 2, log and tree report plug log distribution tables.	IBFR	I1
3	Punch board-foot log and tree summary cards: 0, blank; no cards are punched. 1, board-foot log cards 2, board-foot tree cards 3, punch both types of cards	IBD	I1
4	Write stand table: 0, blank, no 1, yes. *Note:* A stand table will not be produced unless CC10, column 60, is 0, blank, or 1.	ISTN	I1

Card column	Entry on Tally Sheet	Variable name	Statement format
5	Write stock table: 0, blank, none 1, cubic feet (cubic meters) 2, board feet 3, both. *Note:* Cubic-foot (meter) stock tables will be produced only if CC2, column 70, is punched 2, 3, 4, 5, or 6.	ISTK	I1
6-10	Maximum scaling length for logs in feet and tenths (meters and tenths).	BL	F5.1
11-15	Trim allowance for logs in feet and tenths (meters and tenths).	TR	F5.1
16-20	Minimum log length to be scaled. Sections shorter than this will be disregarded. Use feet and tenths (meters) and tenths).	AML	F5.2
21-23	Blank		3X
24-25	Product (grade) code for the product to be divided into logs and scaled.	IST	A2
26-30	Largest sample-plot number recorded. If blank or 0, no first-stage sampling statistics will be calculated.	JPLOTS	I5
31-35	Terminating (top) diameter outside bark for interpolation.	PLPDOB	F5.1
36-40	Intermediate diameter outside bark for interpolation.	SAWDOB	F5.1
41-45	Terminating (top) diameter inside bark for interpolation.	PLPDIB	F5.1
46-50	Intermediate diameter inside bark for interpolation.	SAWDIB	F5.1
51-55	Minimum fixed top diameter for projection. If blank or 0, 45% d.b.h. will be used.	DPROJ	F5.1
56	Blank		
57	Type of defect deductions: 0, blank no deduction 1, percent deduction 2, volume deduction	IDED	I1
58	Defect deduction applies to: 1, International ¼ inch rule 2, Scribner rule	ITD	I1

Card column	Entry on Tally Sheet	Variable name	Statement format
	3, Doyle rule 4, cubic feet (meters)		
59	Blank		1X
60	Growth projection method 0, blank; no growth or product change 1, change products 2, add two times growth 3, add two times growth, and change products 4, subtract two times growth 5, subtract two times growth, and change products	IGROW	I1
61-63	Blank		3X
64-65 69-70	These two entries of grade provide for two product codes for diameters greater than midpoint diameter that should not be changed when the above options of 1, 3, or 5 are used.	IXX IPL	P2 A2
66-68	Blank		3X
71-72	Blank		2X
73-76	Blank or job identifier	(not read)	
77-80	Control card number	(not read)	

If any of the 10 control card variables are not needed, they may be left blank.

SPECIAL CRUISES

The use of IQ (CC2), CC6, XTRA and XTRB provide several alternatives of sample design to the user. One or all of these variables may be used at the same time. Following are some suggested uses.

1. Simple 3-P sample: A situation where all trees in the population are volume predicted, (i.e., a 100 percent tree mark with 3-P sample)

   IQ = 1
   LS1 = 2 (CC2, column 66)
   CC3 = Number of trees estimated
   CC4 = Aggregate of predictions (board feet, cubic feet, or cubic meters of the marked trees)
   CC5 = Blank
   CC6 = Blank
   CC7 = Number of trees estimated (same as CC3)
   CC8 = Aggregate of prediction (same as CC4)
   XTRA = Blank
   XTRB = Blank

2. Simple 3-P sample with blow-up factor: A situation where all trees have been marked, and fixed-area plots are installed to determine the marked volume per acre. A 3-P subsample is selected from the plot-selected trees.

   IQ = –1
   LS1 = 1 (CC2, column 66) CC3, CC4, CC7, CC8 are blank
   CC6 = Total area in tract/acres in plots
   Record volume and d.b.h. for all trees included on the plots on the tree data sheet (figure 3).
   XTRA = Blank
   XTRB = Blank

3. A point sample cruise with equal point distribution for all timber typers using the same BAF prism with a 3-P selected subsample.
   IQ = BAF*100* total area/number of points.
   LS1 = 1
   CC3, CC4, CC6, CC7, CC8 = Blank
   XTRA = Blank
   XTRB = Blank

4. A point sample cruise with two or more strata with a different relationship of area per point with a 3-P selected subsample.
   IQ = –BAF*100
   LS1 = 1
   CC3, CC4, CC7, CC8 = Blank
   CC6 = area of each stratum/points in each stratum
   XTRA = Blank
   XTRB = Blank

5. A cruise using point-selected trees of different BAF for each stratum where area per point is the same for all strata.
   IQ = –BAF*100* area per point, where BAF is that of the lowest factor used.
   LS1 = 1
   CC6 = Enter "1" in the lower BAF stratum. Entries in each of the other strata will be the result of its BAF divided by the lowest BAF
   XTRA = Blank
   XTRB = Blank

   Example:
   Stratum 1 has BAF of 20
   Stratum 2 has BAF of 10
   Stratum 3 has BAF of 30

   In CC6 enter 2 in columns 1-8
   enter 1 in columns 9-16
   enter 3 in columns 17-24

6. A point sample cruise with two or more strata with a different relationship of area per point, and using a different BAF for pole and mature sized trees with a 3-P selected subsample.

   IQ = –100
   LS1 = 1
   CC3, CC4, CC7, CC8 = Blank
   CC6 = area of each stratum/points in each stratum

XTRA = BAF used for point selected tree
XTRB = Blank

The six preceding sample designs are a few examples of how these variables may be used. Because each inventory of cruise presents a different situation, no attempt has been made to cover all the possibilities. Some general notes on sample design variables may be useful.

IQ = When IQ is greater than 1, or blank, CC6, XTRA, and XTRB are program-transformed to positive unity, or equal to 1. Simple 3-P designs use this option with LS1 equal to 1 when all predicted values are entered on three cards, or LS1 equals 2 when the aggregate of the predicted values is entered from CC3, CC4, CC7, and CC8.

When IQ is ± 1, a wide variety of designs that do not employ horizontal point-sampling may be used, such as inventory remeasurement where predetermined frequency factors for trees are used in XTRA or as blowup factors on CC6 for each stratum.

When IQ is either more or less than one, it becomes a constant multiplier for horizontal point sampling. (QI equals IQ/100 for US units, QI equals IQ/1000 for metric units.) IQ is used in this manner for a wide range of multistage designs and is a multiplier for all trees and strata that follow.

CC6 = This variable is used only when IQ is negative and is a constant for all trees in a given stratum (it may vary for each of the nine stratum) that appears in frequency computations whether or not point sampling is involved.

XTRA = This variable is a multiplier when IQ is a negative variable that may vary from tree to tree, and applies only to the tree against which it is entered. XTRA may be the product of several factors acting together, such as BAF, slope, slopover correction factors used in point sampling or direct input of population frequency represented by the sample tree from earlier computation. XTRA becomes especially useful for periodic updating of an inventory.

XTRB = This variable is a divisor when IQ is a negative variable that may vary from tree to tree, but XTRB applies only to the tree against which it is entered. It also may be the product of several divisors acting together. For each relative probability, a corresponding factor must be present in CC6 to convert relative probabilities to absolute. XTRB is particularly important for many of the multistage sampling designs not included in this paper.

COMMON ERRORS OF INPUT DATA

The crew should make a field audit of the STX sheet before leaving the tree. Following is a partial list of items to check:

1. A prediction greater than the largest random number indicates a sure-to-measure tree. (Check all predictions on multistage cruise).
2. The tree and/or plot number should be the same on tree card and dendrometer cards.
3. Be sure the symbols (=) or (*) are recorded in column 11, for a sample tree. (An asterisk, (*), must be in column 72 or dendrometer cards must follow).
4. The plus symbol (+) should be recorded in column 72. The "+" is only used on a forked tree or when the dendrometer is moved. The next reading must be on a *base* and start on the next card.
5. Be sure an asterisk (*) is recorded in column 72 of the last card.
6. Is the GR column filled out? If you want a board-foot volume printout, all sawtimber must be recorded using the same grade code specified in columns 24 and 25 of CC10.
7. Column 25 of the tree card continuation should be properly coded for forked trees if there are less than four uninterrupted measurements.

DIAGNOSTICS AND ERRORS

Error messages resulting from input data found by STX subroutine ST11. NERR in the output indicates the type of error (figure 64).

ST11

Octal	Probable cause of error
1	Data deck jumbled or mispunched (sampling class - column 11 - not =, *, or blank).
2	Data deck jumbled, tree card mispunched or out of order, or previous TERM not "*".
3	Errors 1 and 2
4	Tree stratum greater than maximum number of strata listed on control card 2.
5	Errors 1 and 4
6	Errors 2 and 4
7	Errors 1, 2, and 4
20	DBH (column 17-21) omitted and absolute value of CC2 column 56-64 greater than 1. (Variable plot).
100	Prediction greater than maximum specified on control card 2, less than or equal to 0, or omitted and sampling class not "=".
200	Sampling class is blank, indicating a predicted only tree, but first STX job option is 2 or 4. (CC2 column 66).
400	Inappropriate units of measure. Column 65 on the second control card and column 22 on each tree card should be blank for U.S. units and a plus symbol (+) used for metric measurements.
500	Errors 100 and 400.
600	Errors 200 and 400.
700	Errors 100, 200 and 400.

An example of some of these error messages is given in figure 76.

Examples of some of these errors are also given in the following list. Error messages are printed for errors encountered by subroutine ST22.

ST22

error code	Probable cause of error
1	Implies a negative diameter was recorded arising from a faulty, unseen length projection.
2	Implies a machine error in failing to branch properly on the symbols +, *, or for spaces left blank, or failure to copy these symbols correctly from the input tape.
3	Implies a negative length was recorded because of faulty dendrometry (progressing from top to stump, etc.), faulty

punching, or faulty unseen length projection. (A downward progression must be repunched in an upward progression.)

4 Implies a disarranged data deck or faulty punching. Failure to punch a terminal asterisk can cause this error, as can variations in tree card numbers (caused by faulty punching) within tree sequence. The most common cause is failure to be in arithmetic progression with a unit interval starting with zero.

5 Implies an earlier machine error (in ST11) resulting in failure to detect faulty data with a stratum number larger than the maximum specified on the second control card.

6 Implies machine error in failing to branch properly on a sure-to-be-measured tree or in earlier failure to detect faulty data with a sample tree having a blank, zero, or negative prediction larger than the value specified in CC2, columns 51 to 55.

7 Implies an inadequate number of measured diameters were recorded for projection computations (There must be at least four diameter measurements when column 25 of the tree card is punched with code 2, and at least two diameter measurements must be recorded without any projection at all).

```
THE INTERPRETATION OF MEANINGLESS INPUT WAS ATTEMPTED.
THE FOLLOWING RECORD IS ERRONEOUS OR DOES NOT CORRESPOND TO FORMAT SPECIFICATIONS:
   41       -99919.8   3.5       17.2  4.5ST 450 811-1015ST 465 756 0710ST    .7    1
  I/O  CALLED  AT  SEQUENCE  NUMBER 000374  OF  ST11


THE INTERPRETATION OF MEANINGLESS INPUT WAS ATTEMPTED.
THE FOLLOWING RECORD IS ERRONEOUS OR DOES NOT CORRESPOND TO FORMAT SPECIFICATIONS:
0007 00351*BS15 00105 12 00006                                                100001
  I/O  CALLED  AT  SEQUENCE  NUMBER 000640  OF  ST11



ERRORS ENCOUNTERED IN EDIT OF TREE CARDS --

    NERR =    4      JOB = TEST
    TREE NUMBER    3  PLOT NUMBER    4  CARD NUMBER 0  PREDICTION   55  VALUE STRATUM 2
    SAMPLING CLASS *  TERM      PREVIOUS TREE NUMBER    1


    NERR =   20      JOB = TEST
    TREE NUMBER    4  PLOT NUMBER    1  CARD NUMBER 0  PREDICTION   85  VALUE STRATUM 1
    SAMPLING CLASS *  TERM      PREVIOUS TREE NUMBER    0


    NERR =  100      JOB = TEST
    TREE NUMBER    1  PLOT NUMBER    3  CARD NUMBER 0  PREDICTION  100  VALUE STRATUM 1
    SAMPLING CLASS *  TERM      PREVIOUS TREE NUMBER    1
```

Figure 64.–Printout of error messages encountered in ST11.

After printing any of these seven error messages, ST22 will continue to process and print individual tree data. Further summarization or processing is suppressed (after 25 error messages or misarrayed cards), but ST33 produces a summary printout for data processing statistics, page number of which is always zero. (refer page 118.) This printout contains two messages, one showing the number of input flaws that blocked processing a second identifying, by tree number and plot number, sample trees containing suspicious data. Input data and outputs for these trees should be closely examined. Reasons for suspicion are lack of recorded d.b.h. (the program uses the second set of dendrometer measurements as a substitute, but omits the tree from summaries of basal area); a population frequency of one or less for a 3-P sample tree (no sample drawn without replacement can represent less than itself, a tree with F = 1 should be a sure-to-be-measured tree); or an upper d.o.b. more than 0.5 inch (1 cm) larger than its next lower d.o.b.

The amounts of input and processing done before encountering fatal flaws is helpful in verifying that the same number of tree cards was read by ST11 and ST22 and that later processing was completed for all measured trees.

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APPENDICES

APPENDIX 1. – ORGANIZATION OF SUBROUTINES IN STXMOD

The STXMOD computer program is made up of 28 subroutines; when they are overlayed they are structured as indicated in figure 65.

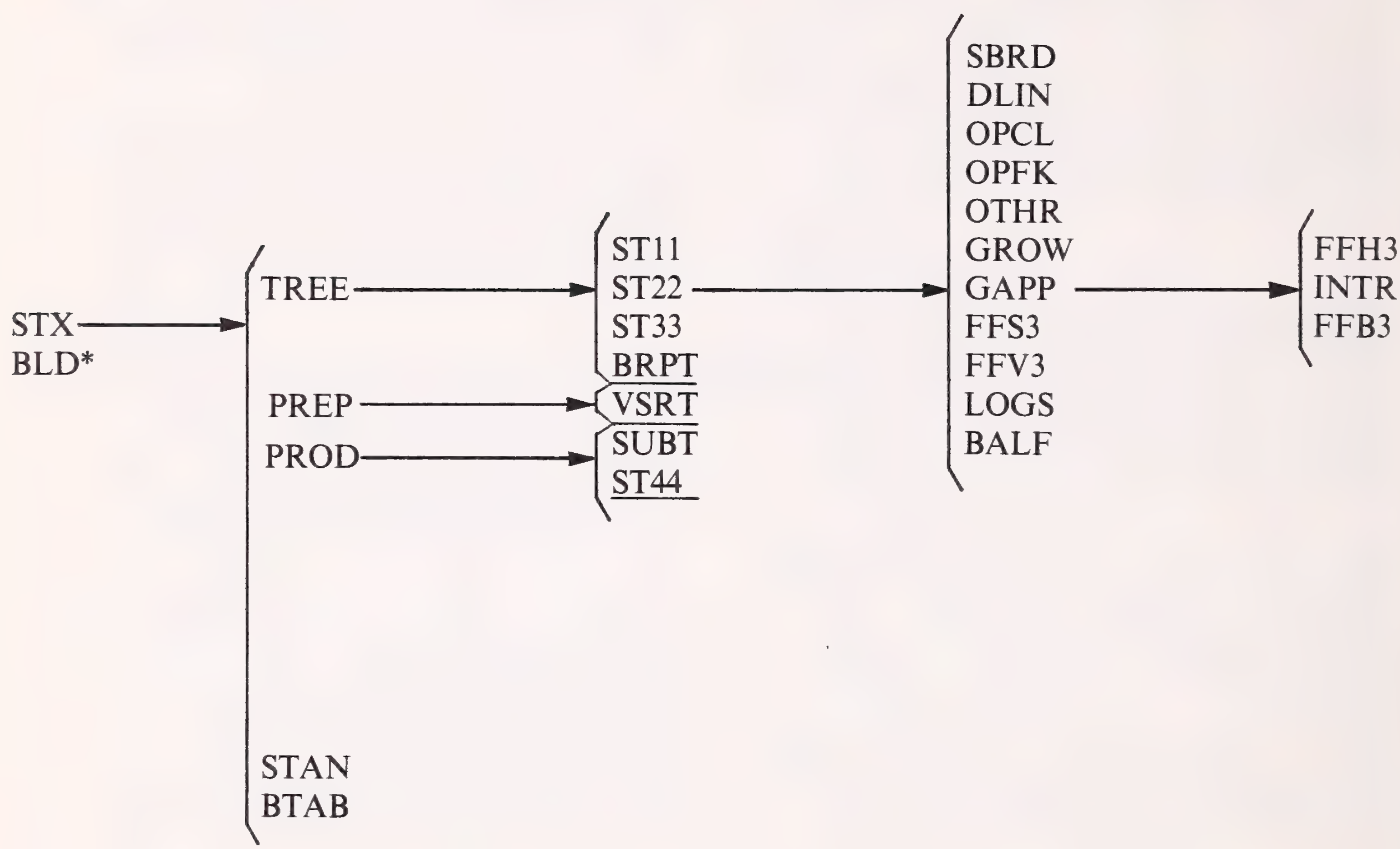

Figure 65.–Subroutines for the STXMOD computer program.

*Block data subprogram

APPENDIX 2. – DESCRIPTION OF SUBROUTINES IN STXMOD

Subroutine	Purpose
STX	Executes the program for 3-P sample tree measurement computations; reads the first two control cards.
BLD	Provides the block data deck for setting up constants needed by STX.
TREE	Does probability and geometric calculations; summarizes basic population statistics.
PREP	Sorts log data.
PROD	Produces grade-yield, product outturn and realization reports.
STAN	Produces stand tables by class.
BTAB	Produces board-foot log distributions and stock tables.
ST11	Edits input; accumulates the population frequency and relative probability for each tree-sampling category.
ST22	Edits the sample-tree portion of the input; calculates log and tree V.S.L., frequency, basal area, predictions and quantities for the sampling error. Prints out a detailed tree and log report.
ST33	Combines aggregrate population estimates; computes the sampling error; and prints a summary report.
BRPT	Writes the board-foot log and tree report.
VSRT	Sort-merge subroutine.
SUBT	Subtotals V.S.L.
ST44	Converts V.S.L. to grade yield, product outturn or realizations.
SBRD	Converts Barr and Stroud dendrometer readings to diameter, elevation and range in ST22.
DLIN	Converts linear measurements to diameter, elevation and range in ST22.
OPCL	Processes optical caliper measurements.
OPFK	Processes optical fork measurements.
OTHR	Executes any user-developed subroutine to process dendrometer readings.
GROW	Predicts past or future upper-stem diameters using a radial increment.
GAPP	Supplies missing tree-variables for ST22; reduces measurements for bark; projects figures for unmeasured upper stems.
FFS3	Executes any user-developed function for the uppermost surface area.
FFV3	Executes any user-developed function for uppermost volume.
LOGS	Divides tree measurements into logs by interpolation.
BALF	Does frequency balancing.
FFH3	Executes any user-developed function for the unseen length from seen part of a tree.
INTR	Interpolates to specific diameters.
FFB3	Executes the use and developed functions for bark; calculates d.i.b. with bark model #3

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DENDROMETRY EXAMPLES AND OPTIONS                                         TEST  PAGE    6
CRC 8-04-80                                        2     400.   160       15467 123020
                          DETAILED LOG AND/OR TREE REPORT
==========================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /   DIB    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /   IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
==========================================================================================
             12.4       73.7     36.0       5.4          .0        .0     6.4   36.0000
             16.8       72.6     25.0      10.2          .0        .0    12.0   25.0000
             15.3       53.6     15.0      12.0          .0        .0    14.1   15.0000
              6.5       19.2      4.5      15.3          .0        .0    18.0    4.5000
               .0         .0       .0      17.3          .0        .0    20.4     .0000
------------------------------------------------------------------------------------------
   1 SUMS   51.0     219.1     80.5   /   18.0 = D.B.H.     FREQUENCY =          87.525
     PREDICTION =      0   D.B.T. =   2.70   FORK    OPTIONS = 2110 UNSEEN MATERIAL
     CLASS = DIRE     VALUE STRATUM =   1     BASAL AREA =    1.77
     PLOT OR POINT NUMBER      10     GROWTH =       .00
******************************************************************************************
             13.7       77.6     36.0       5.8          .0        .0     6.4   36.0000
             18.1       75.3     25.0      10.7          .0        .0    12.0   25.0000
             15.7       54.3     15.0      12.4          .0        .0    14.1   15.0000
              6.4       18.9      4.5      15.3          .0        .0    18.0    4.5000
               .0         .0       .0      16.9          .0        .0    20.4     .0000
------------------------------------------------------------------------------------------
   2 SUMS   53.8     226.2     80.5   /   18.0 = D.B.H.     FREQUENCY =          87.525
     PREDICTION =      0   D.B.T. =   2.70   FORK    OPTIONS = 2210 UNSEEN MATERIAL
     CLASS = DIRE     VALUE STRATUM =   1     BASAL AREA =    1.77
     PLOT OR POINT NUMBER      10     GROWTH =       .00
******************************************************************************************
             11.3       70.3     36.0       5.1          .0        .0     6.4   36.0000
             15.9       70.5     25.0       9.8          .0        .0    12.0   25.0000
             15.0       53.0     15.0      11.7          .0        .0    14.1   15.0000
              6.7       19.4      4.5      15.3          .0        .0    18.0    4.5000
               .0         .0       .0      17.6          .0        .0    20.4     .0000
------------------------------------------------------------------------------------------
   3 SUMS   48.8     213.2     80.5   /   18.0 = D.B.H.     FREQUENCY =          87.525
     PREDICTION =      0   D.B.T. =   2.70   FORK    OPTIONS = 2310 UNSEEN MATERIAL
     CLASS = DIRE     VALUE STRATUM =   1     BASAL AREA =    1.77
     PLOT OR POINT NUMBER      10     GROWTH =       .00
******************************************************************************************
```

Example of the Three Bark Options

Upper stem bark ratio of d.i.b. to d.o.b equal to ratio of d.b.h.i.b. to d.b.h.o.b. (MBK = 1)
Direct measurement

Upper stem bark ratio increases curvilinearly from breast height (MBK = 2)
Direct measurement

Upper stem bark ratio decreases curvilinearly from breast height (MBK = 3)
Direct measurement

Figure 66.–Computer output for Tele-Relaskop (METH = 9) measurements of three bark options.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
1		1	=	DIXIE	18.0	2	1	1	0	1.3	1.4		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	10

Dendrometry Data

TREE NO. (1–4)	J (5)	T GRADS	F GRADS	SINELV	GR	72
1	1	12	16: 20.4	20: 0.0	25	
		27	31: 18.0	35: 4.5	40	
		42	46: 14.1	50: 15.0	55	
		57	61: 12.0	65: 25.0	70	
	2	12	16: 6.4	20: 36.0	25	
		27	31	35	40	
		42	46	50	55	
		57	61	65	70	*
	3	12	16	20	25	
		27	31	35	40	
		42	46	50	55	
		57	61	65	70	
	4	12	16	20	25	
		27	31	35	40	
		42	46	50	55	
		57	61	65	70	

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)
	10

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2-78 CC

Figure 67.–Sample recording sheet and dendrometry data for tree number 1, in figure 66.

SAMPLE TREE RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
2		1	=	DIRE	18.0	2	2	1	0	1.3	1.4		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	10

Dendrometry Data

TREE NO. (1–5): 21

Cols. 1-4, 73-80 are in every card.

Card	J	T GRADS	F GRADS	SINELV	GR	
1	12		16: 20.4	20: 0.0	25	
	27		31: 18.0	35: 4.5	40	
	42		46: 14.1	50: 15.0	55	
	57		61: 12.0	65: 25.0	70	72
2	12		16: 6.4	20: 36.0	25	
	27		31	35	40	
	42		46	50	55	
	57		61	65	70	72: *
3	12		16	20	25	
	27		31	35	40	
	42		46	50	55	
	57		61	65	70	72
4	12		16	20	25	
	27		31	35	40	
	42		46	50	55	
	57		61	65	70	72

GROWTH (73–76)	CFI POINT NO. (77–80)
	10

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2-78 CC

Figure 68.–Sample recording sheet and dendrometry data for tree number 2, in figure 66.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
3		1	=	DIRE	18.0	2	3	1	0	1.3	1.4		

XTRA 42–56

XTRB 57–71

Percent or Volume Deduction 73–76

CFI Point No. 77–80: 10

Dendrometry Data

TREE NO. (1) J (5): 3 1

Cols. 1–4, 73–80 are in every card.

Card	Cols.	T GRADS	F GRADS	SINELV	GR	72
1	12 / 16 / 20 / 25		20.4	0.0		
	27 / 31 / 35 / 40		18.0	4.5		
	42 / 46 / 50 / 55		14.1	15.0		
	57 / 61 / 65 / 70		12.0	25.0		
2	12 / 16 / 20 / 25		6.4	36.0		
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					
	57 / 61 / 65 / 70					✱
3	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					
	57 / 61 / 65 / 70					
4	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					
	57 / 61 / 65 / 70					

GROWTH 73–76

CFI POINT NO. 77–80: 10

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2–78 CC

Figure 69.–Sample recording sheet and dentrometry data for tree number 3, in figure 66.

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DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE   9
CRC 6-04-80                                     2     400.   160     15467 123020
                           DETAILED LOG AND/OR TREE REPORT
==================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /   DIB    / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /   IN.    /CODE/  FT./ TGRADS  FGRADS   SINELV
==================================================================================
            .3        5.3      10.1        .1   TW      .0   -99.9   -99.9     .4140
           3.1       23.5      14.9       3.9   TW   117.9    53.0    59.2     .3420
            .0         .0        .0       8.2        110.0    52.1    65.5     .2315
          10.0       50.5      20.5       8.2   ST    73.3    45.0    66.1     .8055
          28.0       99.5      28.6      10.7   ST    68.6    43.4    72.2     .5633
           7.8       21.5       4.7      16.0   ST    64.3    41.7    86.0     .1565
          16.0       38.6       7.4      18.9   ST    61.8    40.6    94.6     .0865
            .0         .0        .0      21.0         61.8    40.6   100.4    -.0330
----------------------------------------------------------------------------------
   6 SUMS   65.1      238.9      86.1  /   21.2 = D.B.H.    FREQUENCY =      109.006
     PREDICTION =     93  D.B.T. =   2.10   FORK   OPTIONS = 1210 UNSEEN MATERIAL
     CLASS = BS15    VALUE STRATUM =  1    BASAL AREA =   2.45
     PLOT OR POINT NUMBER      11    GROWTH =      1.20
**********************************************************************************
           3.4       29.8      25.0       1.1   TW      .0      .0   -99.9     .0000
           4.4       25.7      12.0       8.0   TW    50.8    33.7    66.4     .4310
            .0         .0        .0       8.3         48.2    31.4    67.3     .2040
           1.2       11.0       8.0       4.3   TW    57.4    36.3    54.3     .6485
           2.0       14.2       8.0       6.2   TW    54.2    36.3    60.3     .5385
           1.9       11.7       5.7       7.3   TW    49.7    32.8    64.0     .4260
           2.7       15.2       6.8       8.3   XX    48.1    31.3    67.6     .3220
            .0         .0        .0       8.8         46.0    29.0    69.4     .1900
           5.4       23.9       8.6       8.8   ST    46.0    29.0    69.4     .1900
           3.5       13.2       4.0      12.6   ST    45.4    28.3    83.5     .0040
           1.5        5.4       1.5      12.7   ST      .0      .0    14.0    4.0000
            .0         .0        .0      14.8           .0   -99.9    16.7    1.5000
----------------------------------------------------------------------------------
   8 SUMS   26.0      150.0      79.6  /   14.0 = D.B.H.    FREQUENCY =      144.685
     PREDICTION =     80  D.B.T. =   1.30   FORK * OPTIONS = 1220 UNSEEN MATERIAL *
     CLASS = BS15    VALUE STRATUM =  1    BASAL AREA =   1.07
     PLOT OR POINT NUMBER      11    GROWTH =       .75
**********************************************************************************
```

Figure 70.–Computer output of data obtained for upper portion of stem or forked tree, with Barr and Stroud dendrometer.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	S r. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
6	93	1	*	8515	21.2	1	2	1	0	1.1	1.0		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	11

Dendrometry Data

TREE NO. (1–4): 6 J (5): 1

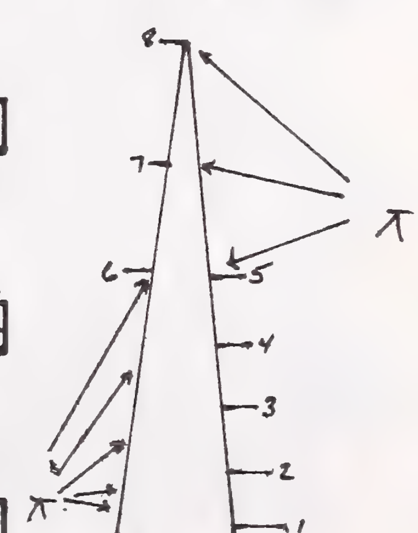
Cols. 1-4, 73-80 are in every card.

J	Cols.	T GRADS	F GRADS	SINELV	GR		72
1	12 / 16 / 20 / 25	406	1004	9670			
	27 / 31 / 35 / 40	406	946	10865	S	T	
	42 / 46 / 50 / 55	417	860	11565	S	T	
	57 / 61 / 65 / 70	434	722	15633	S	T	
2	12 / 16 / 20 / 25	450	661	18055	S	T	
	27 / 31 / 35 / 40						
	42 / 46 / 50 / 55						
	57 / 61 / 65 / 70						+
3	12 / 16 / 20 / 25	521	655	12312			
	27 / 31 / 35 / 40	530	592	13420	T	W	
	42 / 46 / 50 / 55	-999	-999	14140	T	W	
	57 / 61 / 65 / 70						*
4	12 / 16 / 20 / 25						
	27 / 31 / 35 / 40						
	42 / 46 / 50 / 55						
	57 / 61 / 65 / 70						

GROWTH (73–76)	CFI POINT NO. (77–80)
1.2	11

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 CC

Figure 71.–Sample recording sheet and dendrometry data obtained for upper portion of stem, in figure 70.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
8	80	1	=	B515	140	1	2	2	0	.7	.6	25	.3

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
20	11

Dendrometry Data

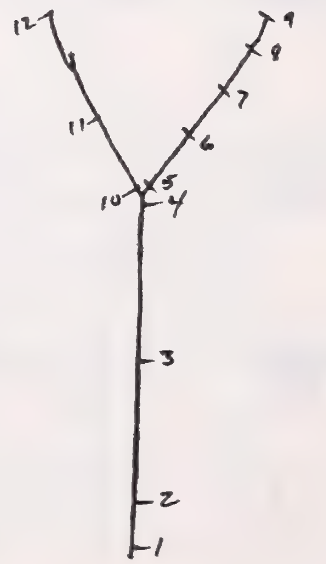
Cols. 1-4, 73-80 are in every card.

TREE NO. (1–4)	J (5)	T GRADS	F GRADS	SINELV	GR	72
8	1	(12) -999	(16) 16.7	(20) 1.5	(25)	
		(27)	(31) 14.0	(35) 4.0	(40) ST	
		(42) 283	(46) 835	(50) 10040	(55) ST	72
		(57) 290	(61) 694	(65) 11900	(70) ST	+
	2	(12) 290	(16) 694	(20) 11900	(25)	
		(27) 313	(31) 676	(35) 13220	(40) XX	
		(42) 328	(46) 640	(50) 14260	(55) Tw	72
		(57) 363	(61) 603	(65) 15385	(70) Tw	
	3	(12) 383	(16) 543	(20) 16485	(25) Tw	
		(27)	(31)	(35)	(40)	
		(42)	(46)	(50)	(55)	72
		(57)	(61)	(65)	(70)	+
	4	(12) 314	(16) 673	(20) 12040	(25)	
		(27) 337	(31) 664	(35) 14310	(40) Tw	
		(42)	(46) -999	(50)	(55) Tw	72
		(57)	(61)	(65)	(70)	*

GROWTH (73–76)	CFI POINT NO. (77–80)
.75	11

LEAN deg.

Sketch tree below



For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _____

Dendrometer set up: bearing _____ distance _____

2-78 C(

Figure 72.–Sample recording sheet and dendrometry data obtained for forked tree, in figure 70.

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DENDROMETRY EXAMPLES AND OPTIONS                                          TEST  PAGE  10
CRC 8-04-80                                               2    400.   160     15467 123020
                              DETAILED LOG AND/OR TREE REPORT
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TREE/  VOLUME   / SURFACE / LENGTH /   DIB   / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /    FT.  /   IN.   /CODE/  FT./ TGRADS  FGRADS    SINELV
==========================================================================================
           1.8       13.2       7.6       5.8   PW    91.1     1.9    6.81     .3145
            .0         .0        .0       7.4   PW    88.1     1.9    9.08     .2830
           1.8       11.8       6.3       6.9   PW    90.4     1.5    8.21     .3100
            .0         .0        .0       7.5   PW    87.9     1.6    9.13     .2815
            .4        2.4       1.1       7.8   ST    79.5      .0   10.50     .2330
           4.7       25.4      11.0       8.4   ST    79.1      .0   11.40     .2245
          11.9       58.3      22.7       9.2   ST    75.5      .0   13.20     .1500
           3.3       12.8       4.0      10.4   ST    73.0      .0   15.50    -.0230
           4.1       13.5       3.5      14.0   ST      .0      .0   15.60    4.0000
            .0         .0        .0      15.5           .0   -99.9   17.50    3.5000
------------------------------------------------------------------------------------------
  2 SUMS  28.0      137.4      56.3  /  15.6 = D.B.H.    FREQUENCY =           116.528
    PREDICTION =     95  D.B.T. =  1.60  FORK * OPTIONS = 4210 UNSEEN MATERIAL
    CLASS = TRAN    VALUE STRATUM =  1    BASAL AREA =  1.33
    PLOT OR POINT NUMBER     14    GROWTH =     .70
******************************************************************************************
           1.2       12.6      11.7       2.0   TW    93.4     2.5    2.27     .3330
           6.8       47.0      26.0       6.2   ST    88.2     3.0    7.53     .2800
          12.9       69.5      30.0       7.6   ST    80.5     3.5   10.16     .1430
           4.4       15.7       4.5      10.1   ST    78.0     3.5   14.01    -.0315
           5.9       16.1       3.5      16.5   ST      .0      .0   18.50    4.5000
            .0         .0        .0      18.7           .0   -99.9   21.40    3.5000
------------------------------------------------------------------------------------------
  8 SUMS  31.2      160.8      75.7  /  18.5 = D.B.H.    FREQUENCY =            82.858
    PREDICTION =      0  D.B.T. =  2.00  FORK   OPTIONS = 4210 UNSEEN MATERIAL
    CLASS = TRAN    VALUE STRATUM =  2    BASAL AREA =  1.87
    PLOT OR POINT NUMBER     14    GROWTH =     .00
******************************************************************************************
           1.5       14.9      12.1       2.7   TW    72.1      .0    4.00     .3000
           3.7       17.3       6.7       6.6   ST    66.9      .0   10.50     .2100
           7.4       24.7       6.6      13.3   ST    64.8      .0   22.10     .1530
            .0         .0        .0      15.4         63.4      .0   26.60     .0945
          22.8       65.8      15.1      16.0   ST   120.3      .0   14.60     .1640
           6.7       19.5       4.5      17.3   ST   116.9      .0   16.40     .0934
           5.4       15.4       3.5      15.8   ST      .0      .0   17.30    4.5000
            .0         .0        .0      17.8           .0   -99.9   19.80    3.5000
------------------------------------------------------------------------------------------
  9 SUMS  47.6      157.6      48.4  /  17.3 = D.B.H.    FREQUENCY =            94.752
    PREDICTION =      0  D.B.T. =  1.50  FORK   OPTIONS = 4210 UNSEEN MATERIAL
    CLASS = TRAN    VALUE STRATUM =  2    BASAL AREA =  1.63
    PLOT OR POINT NUMBER     14    GROWTH =     .00
******************************************************************************************
```

Figure 73.–Computer output of data obtained in three applications of a transit dendrometer.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
2	95	1	=	TRAW	15.6	4	2			.8	.		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	14

Dendrometry Data

TREE NO. (1–4) 2, J (5) 1

Cols. 1-4, 73-80 are in every card.

J	Col.	T GRADS	Col.	F GRADS	Col.	SINELV	Col.	GR	72
1	12		16	.75	20	-1530	25		
	27	-999	31	17.5	35	3.5	40		
	42		46	15.6	50	4.0	55	ST	
	57		61	15.5	65	-0230	70	ST	
2	12		16	13.2	20	1500	25	ST	
	27		31	11.4	35	2245	40	ST	
	42		46	10.5	50	2330	55	ST	
	57		61		65		70		+
3	12		16	.82	20	-2030	25		
	27	16	31	9.5	35	2815	40	PW	
	42	15	46	8.5	50	3100	55	PW	
	57		61		65		70		+
4	12		16	.82	20	-2030	25		
	27	19	31	9.6	35	2830	40	PW	
	42	19	46	7.2	50	3145	55	PW	
	57		61		65		70		*

GROWTH (73–76)	CFI POINT NO. (77–80)
.7	14

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2–78 CC

Figure 74.–Sample recording sheet and dendrometry data obtained for forked tree, in figure 73.

SAMPLE TREE RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Sr. (10)	★ = (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
8		2	=	TRAN	18.5	4	2	1	0	1.4	.6		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	14

Dendrometry Data

TREE NO. (1–4): 8 J (5)

Cols. 1-4, 73-80 are in every card.

J	Cols.	T GRADS	F GRADS	SINELV	GR	72
1	12 / 16 / 20 / 25		.78	– 830		
	27 / 31 / 35 / 40	–999	21.4	3.5		
	42 / 46 / 50 / 55		18.5	4.5	S T	
	57 / 61 / 65 / 70	35	17.1	– 315	S T	
2	12 / 16 / 20 / 25	35	2.4	1430	S T	
	27 / 31 / 35 / 40	30	8.7	2800	S T	
	42 / 46 / 50 / 55	25	2.5	3330	T W	
	57 / 61 / 65 / 70					*
3	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					
	57 / 61 / 65 / 70					
4	12 / 16 / 20 / 25					
	27 / 31 / 35 / 40					
	42 / 46 / 50 / 55					
	57 / 61 / 65 / 70					

GROWTH (73–76)	CFI POINT NO. (77–80)
	14

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2-78 CC

Figure 75.–Sample recording sheet and dendrometry data obtained for instrument above d.b.h. when the distance is established by a transit dendrometer, in figure 73.

SAMPLE TREE
RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. 1–4	Ht. or Vol. 6–9	Str. 10	★ = 11	Class 12–15	D. B. H. 17–21	Opt. M 23	Opt. B 24	Opt. U 25	Opt. I 26	Bark A 27–30	Bark B 31–34	UML 36–38	UDT 39–41
9		2	=	TRAN	17.2	4	2			.7	.8		

XTRA 42–56	XTRB 57–71

Percent or Volume Deduction 73–76	CFI Point No. 77–80
	14

Dendrometry Data

TREE NO. 1–4: 9 J 5: 1

J	T GRADS	F GRADS	SINELV	GR	72
1	12	16 1.15	20 512	25	
	27 -999	31 19.8	35 3.5	40	
	42	46 17.3	50 4.5	55 ST	72
	57	61 16.4	65 934	70 ST	
2	12	16 14.6	20 1640	25 ST	
	27	31	35	40	
	42	46	50	55	72
	57	61	65	70	+
3	12	16 .63	20 1130	25	
	27	31 26.6	35 945	40	
	42	46 22.1	50 1530	55 ST	72
	57	61 10.5	65 2100	70 ST	
4	12	16 4.0	20 3000	25 TW	
	27	31	35	40	
	42	46	50	55	72
	57	61	65	70	*

Cols. 1-4, 73-80 are in every card.

GROWTH 73–76	CFI POINT NO. 77–80
	14

Sketch tree below

LEAN deg.

For unseen material, total tree ht. _____ unseen merch. length _____ rate of taper _______

Dendrometer set up : bearing _______ distance _______

2-78 CC

Figure 76.–Sample recording sheet and dendrometry data obtained when transit dendrometer is moved to measure upper portion of stem, in figure 73.

```
DENDROMETRY EXAMPLES AND OPTIONS                                        TEST  PAGE  11
CRC 8-04-80                                         2     400.   160      15467 123020
                         DETAILED LOG AND/OR TREE REPORT
======================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /   DIB   / LOG/RANGE/    INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /   IN.   /CODE/  FT./ TGRADS  FGRADS     SINELV
======================================================================================
                .5       9.6      18.8        .1   PW       .0   -99.9 -99.90     .2131
               2.3      24.4      20.6       3.8   PW     76.1     3.0   5.46     .0816
                .0        .0        .0       5.2          75.6    -3.0   7.62    -.0513
               1.0       7.6       4.5       5.7   PW     86.5     3.0   7.27     .1516
               1.5       9.3       4.5       7.1   PW       .0      .0   8.00    4.5000
                .0        .0        .0       8.7              .0   -99.9  10.00    4.5000
--------------------------------------------------------------------------------------
  10 SUMS     5.4       50.8      48.3   /  10.0 = D.B.H.    FREQUENCY =        840.348
     PREDICTION =    50  D.B.T. =   1.30  FORK    OPTIONS = 4210 UNSEEN MATERIAL
     CLASS = TRAN    VALUE STRATUM =  2    BASAL AREA =    .55
     PLOT OR POINT NUMBER     14    GROWTH =     .00
**************************************************************************************
```

Figure 77.–Computer output of data obtained when a transit dendrometer is moved to a position above the last reading.

SAMPLE TREE RECORDING SHEET FOR STX

DATE 8-10-79 **Tree Data** JCB CREW

Tree No. (1–4)	Ht. or Vol. (6–9)	Str. (10)	★= (11)	Class (12–15)	D. B. H. (17–21)	Opt. M (23)	Opt. B (24)	Opt. U (25)	Opt. I (26)	Bark A (27–30)	Bark B (31–34)	UML (36–38)	UDT (39–41)
110	50	2	*	TRAN	112.0	4	2			.7	.6		

XTRA (42–56)	XTRB (57–71)

Percent or Volume Deduction (73–76)	CFI Point No. (77–80)
	114

Dendrometry Data

TREE NO. (1–4)	J (5)	T GRADS	F GRADS	SINELV	GR	72
10	1	12	16 .83	20 21	25	
		27 -999	31 10.0	35 4.5	40	
		42	46 8.0	50 4.5	55 PW	
		57 30	61 8.4	65 1516	70 PW	+
	2	12	16 .79	20 -1832	25	
		27 -30	31 8.8	35 -513	40	
		42 30	46 6.3	50 816	55 PW	
		57 -999	61 -999	65 2131	70 PW	*
	3	12	16	20	25	
		27	31	35	40	
		42	46	50	55	
		57	61	65	70	
	4	12	16	20	25	
		27	31	35	40	
		42	46	50	55	
		57	61	65	70	

Cols. 1-4, 73-80 are in every card.

GROWTH (73–76)	CFI POINT NO. (77–80)
	14

Sketch tree below

LEAN deg.

For unseen material, total tree ht. ____ unseen merch. length ____ rate of taper ____

Dendrometer set up: bearing ____ distance ____

2-78 CC

Figure 78.–Sample recording sheet and dendrometry data for transit dendrometer in figure 77.

```
         DENDROMETRY EXAMPLES AND OPTIONS                                                TEST   1
         CRC 8-04-80  08000 01964673-11905 15658 2  400  160     15467 123020            TEST   2
                                                                                         TEST   3
                                                                                         TEST   4
                                                                                         TEST   5
                                                                                         TEST   6
                                                                                         TEST   7
                                                                                         TEST   8
          -14                                                                            TEST   9
      2013 16.0  0.5  2.0   ST   14  4.0  8.0  4.0  8.0  4.0 12 1   PL    XX             TEST  10
        4   851*BS12   172 0210   8   7                                                     0001
        41       -99919.8  3.5       17.2  4.5ST 450 811-1015ST 465 756 0710ST         .7    1
        42        483 688 2525ST 517 651 5313ST 524 580 6084TW-999-999 6545TW*         .7    1
      0007 00351*BS15 00105 12 00006                                                      100001
        71       -99913.5  4.0       10.5  4.0ST 396 68210845ST 387 64911675TW         .8    1
        72        399 65112535TW 405 63813060TW 416 58713825TW    -999      TW*        .8    1
      0001 00351*DIRE 00105 221000060004                                                    0002
        11            13.5  0.0      10.5  4.0PW      9.4  4.7PW      8.2  7.1PW     .45    2
        12             8.2  5.3PW     7.7  3.5PW      5.7  3.6PW                  *  .45    2
      0001 01001*ZEIS 00180 321000070008                                                    0003
        11       -999 210  4.0ST      180  8.0ST1007 170 93.2ST1500 170100.0TW       .55    3
        12        1542 140113.5TW1581 120119.2TW-999-999133.3TW                   *  .55    3
      0003 00552*TRAN 00266 431000130013                                                    0004
        31            .856  105  -99932.4  3.5       26.6  5.0ST     28.0  435ST       .7    4
        32            26.5 1008ST    25.5 1630ST     22.0 2420ST     -999       TW*    .7    4
      0001 00752*RELA 00165 531000050004                                                    0005
        11        68.5 4.5 -1.0  68.5 4.2  4.5ST68.5 3.0  6.0ST68.5 2.0 35.0ST         .5    5
        12        68.5 1.5 61.0TW-999-999 70.0TW                                  *    .5    5
      0001 00902*C100 00205 621000030004                                                    0006
        11        90.027.5 -8.0  90.020.5  1.0ST90.018.1 16.0ST90.014.3 30.0ST         .4    6
        12        90.010.0 60.0ST90.0 6.1 80.0TW90.0  .2 92.0TW                   *    .4    6
      0001 00902*C66  00205 721000030004                                                    0007
        11        90.027.5 -8.0  90.020.5  1.0ST90.018.1 16.0ST90.014.3 30.0ST       .37    7
        12        90.010.0 60.0ST90.0 6.1 80.0TW90.0  .2 92.0TW                   *  .37    7
      0002 00902*TODI 00180 82 000040006                                                    0008
        21       -999 210  4.0ST      180  8.0ST3069 432 -6.8ST                   +  .37    8
        22        4572 432  0.0TW4700 356 13.5TW4819 305 19.2TW-999-999 33.3TW*       .37    8
        1    481*TELR   266 9210  13  13                                                       9
        11       -99932.4  3.5        26.6  5.0ST14.1 3.7  9.3ST14.1 3.0 18.0ST        .8    9
        12        14.1 2.5 30.3ST14.1 2.2 47.0ST14.1 1.9 55.0ST                   *    .8    9
        1      1=DIRE   180 2110  13  14                                                      10
        11            20.4  0.0       18.0  4.5       14.1 15.0       12.0 25.0               10
        12             6.4 36.0                                                   *           10
        2      1=DIRE   180 2210  13  14                                                      10
        21            20.4  0.0       18.0  4.5       14.1 15.0       12.0 25.0               10
        22             6.4 36.0                                                   *           10
        3      1=DIRE   180 2310  13  14                                                      10
        31            20.4  0.0       18.0  4.5       14.1 15.0       12.0 25.0               10
        32             6.4 36.0                                                   *           10
        6    931*BS15   212 1210  11  10                                                      11
        61         4061004 9670    406 94610865ST 417 86011565ST 434 72215633ST      1.2   11
        62         450 66118055ST                                                 *  1.2   11
        63         521 65512315    530 59213420TW-999-99914140TW                  *  1.2   11
        8    801*BS15   140 1220   7   6  25 .3                                           20   11
        81       -99916.7  1.5       14.0  4.0ST 283 83510040ST 290 69411900ST+      .75   11
        82         290 69411900    313 67613220XX 328 64014260TW 363 60315385TW       .75   11
        83         383 54316485TW                                                 +  .75   11
        84         314 67312040    337 66414310TW    -999       TW                *  .75   11
        2    951*TRAN   156 42      8                                                         14
        21            .75-1530  -99917.5  3.5       15.6  4.0ST     15.5-0230ST        .7   14
        22           13.2 1500ST    11.4 2245ST     10.5 2330ST                   +    .7   14
        23            .82-2030    16 9.5 2815PW  15 8.5 3100PW                    +    .7   14
        24            .82-2030    19 9.6 2830PW  19 7.2 3145PW                    *    .7   14
        8      2*TRAN   185 4210  14   6                                                      14
        81            .78- 830  -99921.4  3.5       18.5  4.5ST  3517.1- 315ST                14
        82          3512.4 1430ST  30 8.7 2800ST  25 2.5 3330TW                   *           14
        9      2*TRAN   173 42     7   8                                                      14
        91           1.15  512  -99919.8  3.5       17.3  4.5ST     16.4  934ST               14
        92           14.6 1640ST                                                  +           14
        93            .63 1130      26.6  945       22.1 1530ST     10.5 2100ST               14
        94            4.0 3000TW                                                  *           14
       10    502*TRAN   100 42     7   6                                                      14
       101            .83   21  -99910.0  4.5        8.0  4.5PW  30 6.4 1516PW+               14
       102            .79-1832   -30 8.8 -513    30 6.3  816PW-999-999 2131PW*                14
        1    651 BS12   126                                                                    1
        2    721 BS12   131                                                                    1
        3    411 BS12   104                                                                    1
        5    651 BS15   121                                                                    1
        6    141=BS15    24                                                                    1
        2    651 DIRE   129                                                                    2
        2    141=ZEIS    31                                                                    3
        1    712 TRAN   161                                                                    4
        2    682 TRAN   135                                                                    4
        2    552 RELA   117                                                                    5
        2    432 C100    98                                                                    6
        2    652 C66    135                                                                    7
        3    712 C66    148                                                                    7
        1    662 TODI   125                                                                    8
        2   1101 TELR   199                                                                    9
        3   1501 TELR   265                                                                    9
        4      1=TELR    50                                                                    9
      9999
      9999
END DATA. ERRORS: NONE. TIME:  1.183 SEC. IMAGE COUNT: 93
```

Figure 79.–Computer print out of data input.

APPENDIX 4.– STXMOD PROGRAM OUTPUT

```
DENDROMETRY EXAMPLES AND OPTIONS                                        TEST  PAGE  1
CRC 8-04-80                                     2    400.  160     15467 123020
             PRELIMINARY REPORT--COUNTS AND AGGREGATE PREDICTIONS
=====================================================================================

        STRATUM 1                                    TREE COUNTS    PREDICTIONS
-------------------------------------------------------------------------------------
            SURE-TO-BE MEASURED  TREES(=1)              8               203
            THREE-PEE  MEASURED  TREES(*2)              6               396
            THREE-PEE  PREDICTED TREES( 3)              7               568
-------------------------------------------------------------------------------------
                            ALL TREES(1,2,3)      21                   1167
-------------------------------------------------------------------------------------
                   ALL MEASURED  TREES(1,2)       14                    599
                   ALL THREE-PEE TREES(2,3)       13                    964
                 EXPECTED VALUES  FOR (*2)         2.410               211.920
                 EXP. VAL. ST. ERRORS (*2)         1.371               124.085
        STRATUM 2                                    TREE COUNTS    PREDICTIONS
-------------------------------------------------------------------------------------
            SURE-TO-BE MEASURED  TREES(=1)              2                 0
            THREE-PEE  MEASURED  TREES(*2)              6               450
            THREE-PEE  PREDICTED TREES( 3)              7               439
-------------------------------------------------------------------------------------
                            ALL TREES(1,2,3)      15                    889
-------------------------------------------------------------------------------------
                   ALL MEASURED  TREES(1,2)        8                    450
                   ALL THREE-PEE TREES(2,3)       13                    889
                 EXPECTED VALUES  FOR (*2)         2.222               159.027
                 EXP. VAL. ST. ERRORS (*2)         1.351                97.786

     TOTALS FOR ALL 2 STRATA                         TREE COUNTS    PREDICTIONS
-------------------------------------------------------------------------------------
            SURE-TO-BE MEASURED  TREES(=1)        10                    203
            THREE-PEE  MEASURED  TREES(*2)        12                    846
            THREE-PEE  PREDICTED TREES( 3)        14                   1007
-------------------------------------------------------------------------------------
                            ALL TREES(1,2,3)      36                   2056
-------------------------------------------------------------------------------------
                   ALL MEASURED  TREES(1,2)       22                   1049
                   ALL THREE-PEE TREES(2,3)       26                   1853
                 EXPECTED VALUES  FOR (*2)         4.632               370.947
                 EXP. VAL. ST. ERRORS (*2)         1.925               157.984
```

Figure 80.–Computer print out of program output

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                     TEST  PAGE   2
CRC 8-04-80                                        2    400,  160    15467 123020
            PRELIMINARY REPORT--COUNTS AND AGGREGATE PREDICTIONS
================================================================================

                      SUM OF PREDICTIONS BY STRATUM

  PLOT OR                          STRATUM
POINT NUMBER        ALL         1          2
      1           377.00     377.00        .00
      2           100.00     100.00        .00
      3           114.00     114.00        .00
      4           194.00        .00     194.00
      5           130.00        .00     130.00
      6           133.00        .00     133.00
      7           226.00        .00     226.00
      8           156.00        .00     156.00
      9           308.00     308.00        .00
     10              .00        .00        .00
     11           173.00     173.00        .00
     12              .00        .00        .00
     13              .00        .00        .00
     14           145.00      95.00      50.00

  TOTALS         2056.00                889.00
                            1167.00
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE   3
CRC 8-04-80                                          2    400.  160     15467 123020
             PRELIMINARY REPORT--COUNTS AND AGGREGATE PREDICTIONS
====================================================================================

                        STATISTICAL SUMMARY OF PLOT DATA

                       SUMS                             NUMBER
STRATUM     PREDICTIONS       PREDICTIONS**2          OF PLOTS
   1            1167.00           298943.00              14
   2             889.00           150137.00              14
  ALL           2056.00                                  14



                          STANDARD  STANDARD  STANDARD   COEFFICIENT
STRATUM          MEAN    DEVIATION   ERROR    ERROR %   OF VARIATION

   1            83.36     124.550     33.29     39.93       149.42
   2            63.50      84.892     22.69     35.73       133.69
  ALL          146.86                           27.43       102.64
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                         TEST  PAGE   4
CRC 8-04-80                                            2    400.  160     15467 123020
              PRELIMINARY REPORT--COUNTS AND AGGREGATE PREDICTIONS
==================================================================================

PUNCH CONTROL CARDS 3 AND 4 AS FOLLOWS TO PROCESS THIS JOB UNDER
SUMMARY INPUT OPTIONS (WITH '2' OR '4' PUNCHED IN COLUMN 66 OF CONTROL CARD 2) --
      21       15                                                       TEST   3
    1167      889                                                       TEST   4

CONTROL CARDS 5, 6, 7, 8 MUST CONTAIN FOLLOWING FLOATING-POINT INFORMATION FOR OPTIONS
'2' OR '4', REDUCED TO NINE 8-COLUMN FIELDS (BLANKS CAN REPLACE ZEROS, IMPLICIT INPUT FORMAT IS 9F8.0) --

  1.000000     1.000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     TEST   5
  .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     TEST   6
  73.80530     13.33106     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     TEST   7
  1167.000     889.0000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     .0000000     TEST   8

CONTROL CARDS 9 AND 10 --

    -14        0       0       0       0       0       0       0       0TEST   9
02013 16.0    .5  2.0    ST   14  4.0  8.0  4.0  8.0  4.0 12 1             PL    XXTEST  10

ALL SUBSEQUENT FREQUENCIES RESULT FROM ADJUSTMENT SUCH THAT F'=FREQ+(V1+V2*KPI+V3*POUT)*FREQ**2.          KPI SHOULD
INCLUDE BA  IN CASE POINT-SAMPLING IS INVOLVED.  IF V1   AND OTHER V'S ARE 0,  THEN FREQUENCIES ARE UNADJUSTED, ELSE
V'S HAVE BEEN DERIVED TO LEAVE ESTIMATES OF TOTAL VOLUME AND EFFECTIVE KPI UNCHANGED, BUT TO ADJUST FREQUENCY ESTIMATES
SO THEY WILL TOTAL POPULATION COUNT OR BEST SAMPLE-BASED ESTIMATE OF COUNT.  INPUT OPTION '1' OR '2' IS APPROPRIATE
WHEN USER MANUALLY INSERTS ADJUSTED V'S BY BLOCK DATA STATEMENT AFTER INITIAL DERIVATION.  V'S EFFECTIVE FOR THIS RUN =

  .0000000     .0000000     .0000000
  .0000000     .0000000     .0000000
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                   TEST  PAGE   5
CRC 8-04-80                                          2     400.  160     15467 123020
                     DETAILED LOG AND/OR TREE REPORT
=====================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /  DIB    / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.   /  SQ.FT. /   FT.  /  IN.    /CODE/  FT./ TGRADS  FGRADS    SINELV
=====================================================================================
             .2        4.0       8.8       .1   TW      .0   -99.9  -99.9      .6545
            2.1       17.3      11.7      3.4   TW   112.5    52.4   58.0      .6084
           14.9       80.7      35.0      7.9   ST   106.8    51.7   65.1      .5313
           11.2       47.7      16.2      9.7   ST    86.3    48.3   68.8      .2525
           13.6       47.1      13.0     12.8   ST    78.6    46.5   75.6      .0710
            5.7       18.0       4.5     14.8   ST    73.3    45.0   81.1     -.1015
            5.4       15.3       3.5     15.7   ST      .0      .0   17.2     4.5000
             .0         .0        .0     17.8           .0   -99.9   19.8     3.5000
-------------------------------------------------------------------------------------
    4 SUMS  53.1      230.1      92.7  /  17.2 = D.B.H.   FREQUENCY =         181.188
      PREDICTION =    85  D.B.T. =  1.50  FORK   OPTIONS = 0210 UNSEEN MATERIAL
      CLASS = BS12   VALUE STRATUM =  1   BASAL AREA =  1.61
      PLOT OR POINT NUMBER     1    GROWTH =     .70
*************************************************************************************
             .2        2.2       1.8      3.7   TW      .0      .0  -99.9      .0000
            1.2        9.1       5.6      5.3   TW    64.0    41.6   58.7      .3825
            1.0        6.7       3.5      7.0   TW    61.6    40.5   63.8      .3060
            1.7       10.8       5.6      7.5   TW    60.4    39.9   65.1      .2535
            1.6        9.7       4.7      7.4   TW    58.1    38.7   64.9      .1675
            1.7        9.3       4.0      8.4   ST    59.8    39.6   68.2      .0845
            2.3       10.8       4.0      9.3   ST      .0      .0   10.5     4.0000
             .0         .0        .0     11.3           .0   -99.9   13.5     4.0000
-------------------------------------------------------------------------------------
    7 SUMS   9.7       58.7      29.2  /  10.5 = D.B.H.   FREQUENCY =        1180.750
      PREDICTION =    35  D.B.T. =  1.20  FORK   OPTIONS = 1210 UNSEEN MATERIAL *
      CLASS = BS15   VALUE STRATUM =  1   BASAL AREA =    .60
      PLOT OR POINT NUMBER     1    GROWTH =     .80
*************************************************************************************
             .8        5.9       3.6      5.3   PW      .0      .0    5.7     3.6000
            1.0        6.7       3.5      7.1   PW      .0      .0    7.7     3.5000
            1.7       10.5       5.3      7.6   PW      .0      .0    8.2     5.3000
            2.5       15.0       7.1      7.6   PW      .0      .0    8.2     7.1000
            2.1       11.1       4.7      8.6   PW      .0      .0    9.4     4.7000
            2.5       11.1       4.0      9.5   PW      .0      .0   10.5     4.0000
             .0         .0        .0     11.7           .0      .0   13.5      .0000
-------------------------------------------------------------------------------------
    1 SUMS  10.5       60.3      28.2  /  10.5 = D.B.H.   FREQUENCY =        1180.750
      PREDICTION =    35  D.B.T. =  1.00  FORK   OPTIONS = 2210 UNSEEN MATERIAL
      CLASS = DIRE   VALUE STRATUM =  1   BASAL AREA =    .60
      PLOT OR POINT NUMBER     2    GROWTH =     .45
*************************************************************************************
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                   TEST  PAGE  11
CRC 8-04-80                                       2    400.  160     15467 123020
                         DETAILED LOG AND/OR TREE REPORT
=================================================================================
TREE/  VOLUME   / SURFACE / LENGTH /  DIB   / LOG/RANGE/   INSTRUMENT READINGS
 NO./  CU.FT.  /  SQ.FT. /    FT.  /  IN.   /CODE/  FT./ TGRADS  FGRADS    SINELV
=================================================================================
              .5        9.6     18.8         .1   PW      .0   -99.9 -99.90      .2131
             2.3       24.4     20.6        3.8   PW    76.1     3.0   5.46      .0816
              .0         .0       .0        5.2         75.6    -3.0   7.62     -.0513
             1.0        7.6      4.5        5.7   PW    86.5     3.0   7.27      .1516
             1.5        9.3      4.5        7.1   PW      .0      .0   8.00     4.5000
              .0         .0       .0        8.7           .0   -99.9  10.00     4.5000
---------------------------------------------------------------------------------
 10 SUMS    5.4      50.8     48.3  /  10.0 = D.B.H.   FREQUENCY =         840.348
    PREDICTION =    50  D.B.T. =  1.30  FORK   OPTIONS = 4210 UNSEEN MATERIAL
    CLASS = TRAN   VALUE STRATUM =  2   BASAL AREA =    .55
    PLOT OR POINT NUMBER     14   GROWTH =     .00
*********************************************************************************
              .0         .0       .0         .0           .0      .0     .0      .0000
---------------------------------------------------------------------------------
  6 SUMS     .0        .0       .0  /   2.4 = D.B.H.   FREQUENCY =        4923.299
    PREDICTION =    14  D.B.T. =   .00  FORK   OPTIONS = 0110 UNSEEN MATERIAL
    CLASS = BS15   VALUE STRATUM =  1   BASAL AREA =    .03
    PLOT OR POINT NUMBER      1   GROWTH =     .00
*********************************************************************************
              .0         .0       .0         .0           .0      .0     .0      .0000
---------------------------------------------------------------------------------
  2 SUMS     .0        .0       .0  /   3.1 = D.B.H.   FREQUENCY =        2950.906
    PREDICTION =    14  D.B.T. =   .00  FORK   OPTIONS = 0110 UNSEEN MATERIAL
    CLASS = ZEIS   VALUE STRATUM =  1   BASAL AREA =    .05
    PLOT OR POINT NUMBER      3   GROWTH =     .00
*********************************************************************************
              .0         .0       .0         .0           .0      .0     .0      .0000
---------------------------------------------------------------------------------
  4 SUMS     .0        .0       .0  /   5.0 = D.B.H.   FREQUENCY =        1134.328
    PREDICTION =     0  D.B.T. =   .00  FORK   OPTIONS = 0110 UNSEEN MATERIAL
    CLASS = TELR   VALUE STRATUM =  1   BASAL AREA =    .14
    PLOT OR POINT NUMBER      9   GROWTH =     .00
*********************************************************************************
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                  TEST  PAGE  12
CRC 8-04-80                                    2    400,  160     15467 123020
      SUMMARY REPORT--SURE-TO-BE MEASURED TREES PLUS EXPANDED 3P SAMPLES
================================================================================
```

STRATUM 1 — SAMPLE VARIABLES	SURE-TO-BE MEASURED AGGREGATIONS	3P-EXPANDED SAMPLE ESTIMATES	TOTAL SAMPLE ESTIMATES PLUS SURE
TREES(FREQUENCY)	9532.321	2926.470	12458.791
PREDICT.(EF KPI)	31398.010	149101.873	180499.881
B.A.(SQ.FT.O.B.)	1237.4	2745.8	3983.2
LENGTH(FT.)	39210.7	115122.0	154332.8
SURFACE(SQ.FT.I.B.)	95344.4	275187.2	370531.6
VOLUME(CU.FT.I.B.)	20471.0	60764.5	81235.5
REL.VAL.PER MF.UNIT	1.00	1.00	1.00
GROSS MF.UNITS	20471.0	60764.5	81235.5
ST.ERROR(PCT.)	-----	12.0	9.0

COMPONENT ITEMS	(1=) NUMBER	(2*) NUMBER	(1,2) NUMBER
MEASURED TREES	8	6	14
MEASURED LOGS	28	38	66

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                          TEST  PAGE  14
CRC 8-04-80                                          2    400.  160     15467 123020
      SUMMARY REPORT--SURE-TO-BE MEASURED TREES PLUS EXPANDED 3P SAMPLES
========================================================================================

TOTALS ALL  2 STRATA********************************************************************
                        /   SURE-TO-BE   /   3P-EXPANDED  /  TOTAL SAMPLE  /
                        /    MEASURED    /     SAMPLE     /   ESTIMATES    /
      SAMPLE VARIABLES/  AGGREGATIONS  /   ESTIMATES    /   PLUS SURE     /
----------------------------------------------------------------------------------------
    TREES(FREQUENCY)          9709.931          4446.841          14156.771
    PREDICT.(EF KPI)         31398.010        286603.496         318001.504
    B.A.(SQ.FT.O.B.)          1546.7            4690.3             6237.0
    LENGTH(FT.)              50068.6          216772.5           266841.1
    SURFACE(SQ.FT.I.B.)     123604.3          505136.7           628741.0
    VOLUME(CU.FT.I.B.)       27568.4          122279.8           149848.2
    REL.VAL.PER MF.UNIT          1.00              1.00               1.00
    GROSS MF.UNITS           27568.4          122279.8           149848.2
      ST.ERROR(PCT.)          -----               10.1                8.3
    GROSS WTD.MF.UNITS       27568.36         122279.82          149848.18
      ST.ERROR(PCT.)          -----               10.1                8.3

----------------------------------------------------------------------------------------
                               (1=)              (2*)               (1,2)
    COMPONENT ITEMS           NUMBER            NUMBER             NUMBER
----------------------------------------------------------------------------------------
      MEASURED TREES            10                12                 22
      MEASURED LOGS             39                70                109

----------------------------------------------------------------------------------------
MF.UNITS=  CUBIC FEET
 =(    .10000000+01)*(CU.FT.)+(    .00000000   )*(SQ.FT.)+(    .00000000   )*(FT.)
========================================================================================
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE   0
CRC 8-04-80                                         2    400.  160    15467 123020
      SUMMARY REPORT--SURE-TO-BE MEASURED TREES PLUS EXPANDED 3P SAMPLES
===================================================================================


DATA PROCESSING BLOCKED BY   0 INPUT FLAWS.
SAMPLE ESTIMATES INVOLVE   1 SUSPICIOUS ITEMS NUMBERED
             9-  14
INPUT READ BEFORE FLAW,IF ANY---
    CARDS WITH TREE PREDICTIONS ONLY         (FIRST)                             14
    CARDS WITH MEASURED TREE INFO            (FIRST)                             22
    -------------------------------------------------------------------------------
    CARDS WITH MEASURED TREE INFO            (SECOND)                            22
    CARDS WITH ADDITIONAL DENDROMETER INFO   (SECOND)                            45

PROCESSING DONE BEFORE FLAW,IF ANY---
    NUMBER OF MEASURED TREES PROCESSED                                           22
    NUMBER OF MEASURED LOGS PROCESSED                                           109
    TREE CARDS PUNCHED OR WRITTEN                                                 0
    LOG CARDS PUNCHED OR WRITTEN                                                  0
    LABEL ON CARD OUTPUT                                                       TEST

CHECK OF INPUT AGGREGATES WITH EXPANDED 3P SAMPLE
    AGGREGATE NUMBER OF TREES INPUT(1+2+3)                                  36
    SAMPLE ESTIMATE(2 EXPANDED)+NO.SURE(1 EXPANDED IF SB SAMPLE)       14156.771
    STANDARD ERROR OF ESTIMATED NUMBER                                  1495.525
    -------------------------------------------------------------------------------
    AGGREGATE PREDICTIONS(KPI) INPUT(1+2+3) NOT EXPANDED                  2056
    SAMPLE ESTIMATE(2 EXPANDED)+SURE KPI(EXPANDED IF SB SAMPLE)      318001.504
===================================================================================
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                          TEST  PAGE  15
CRC 8-04-80                                         2    400.  160      15467 123020
                          BOARD FOOT LOG AND TREE REPORT
LOG LENGTH 16.0   TRIM ALLOWANCE   .5   MINIMUM LENGTH  2.0    PRODUCT CODE  ST
==========================================================================================
TREE  /  LENGTH  / SCALING /  DIB /           BOARD FOOT VOLUME             /  VOLUME
 NO.  /     FT.   /LGTH. FT./  IN. /   INT. 1/4  / SCRIBNER /   DOYLE   /  CU.FT.
==========================================================================================
           6.2       6.0        7.9         11.6        11.1        5.8          2.1
          16.5      16.0        8.2         41.5        33.0       18.0          6.6
          16.5      16.0        9.1         52.1        43.0       25.9          8.4
          16.5      16.0       10.5         72.4        62.3       42.5         12.8
          16.5      16.0       13.5        124.9       112.6       89.9         21.7
            .0        .0       17.8           .0          .0         .0           .0
------------------------------------------------------------------------------------------
  4       72.2      70.0       17.2=DBH /  302.4       261.9      182.0         51.6
    PREDICTION =    85  D.B.T. =  1.50/      .0          .0         .0           .0
    CLASS = BS12  VALUE STRATUM =  1 /  302.4       261.9      182.0         51.6
    PLOT OR POINT NUMBER =     1  FORM CLASS = .791    FREQUENCY =        181.188
    BASAL AREA =  1.61  PERCENT DEDUCTION =      .00
******************************************************************************************
           8.0       8.0        8.4         18.9        17.6        9.9          4.4
            .0        .0       11.3           .0          .0         .0           .0
------------------------------------------------------------------------------------------
  7        8.0       8.0       10.5=DBH /   18.9        17.6        9.9          4.4
    PREDICTION =    35  D.B.T. =  1.20/      .0        -1.8         .0           .0
    CLASS = BS15  VALUE STRATUM =  1 /   18.9        15.9        9.9          4.4
    PLOT OR POINT NUMBER =     1  FORM CLASS = .000    FREQUENCY =       1180.750
    BASAL AREA =   .60  PERCENT DEDUCTION =  10.00
******************************************************************************************
          12.0      12.0       15.7        124.9       118.8      101.9         19.7
            .0        .0       18.9           .0          .0         .0           .0
------------------------------------------------------------------------------------------
  1       12.0      12.0       18.0=DBH /  124.9       118.8      101.9         19.7
    PREDICTION =   100  D.B.T. =  1.50/      .0          .0         .0           .0
    CLASS = ZEIS  VALUE STRATUM =  1 /  124.9       118.8      101.9         19.7
    PLOT OR POINT NUMBER =     3  FORM CLASS = .000    FREQUENCY =        140.624
    BASAL AREA =  1.77  PERCENT DEDUCTION =      .00
******************************************************************************************
           7.8       7.0       18.4        100.0        99.8       91.3         13.8
          16.5      16.0       19.6        278.4       261.0      244.1         35.7
          16.5      16.0       20.8        315.7       297.4      283.4         58.1
            .0        .0       30.0           .0          .0         .0           .0
------------------------------------------------------------------------------------------
  3       40.8      39.0       26.6=DBH /  694.2       658.2      618.8        107.7
    PREDICTION =    55  D.B.T. =  2.60/      .0          .0         .0           .0
    CLASS = TRAN  VALUE STRATUM =  2 /  694.2       658.2      618.8        107.7
    PLOT OR POINT NUMBER =     4  FORM CLASS = .794    FREQUENCY =        107.970
    BASAL AREA =  3.86  PERCENT DEDUCTION =      .00
******************************************************************************************
```

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                              TEST  PAGE  19
CRC 8-04-80                                              2    400.  160      15467 123020
                        BOARD FOOT STRATUM SUMMARY FOR PRODUCT ST
```

STRATUM	TREES (FREQUENCY)	BASAL AREA	BOARD FOOT VOLUME INTERNATIONAL 1/4	SCRIBNER	DOYLE
1	2006.932	2345.1	177385.7	157822.4	111623.4
2	857.633	1795.5	306466.0	280952.0	237513.8
ALL	2864.565	4140.6	483851.7	438774.4	349137.2

STRATUM	TOTAL LENGTH	VOLUME CU.FT. /	/ BOARD FEET/CUBIC FT. INTERNATIONAL 1/4	SCRIBNER	DOYLE
1	41824.337	35718.5	5.0	4.4	3.1
2	39659.966	51940.9	5.9	5.4	4.6
ALL	81484.303	87659.4	5.5	5.0	4.0

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                      TEST  PAGE  20
CRC 8-04-80                                          2     400.   160     15467 123020
                  BOARD FOOT STRATUM SUMMARY FOR PRODUCT ST
```

STRATUM	AVERAGE FORM CLASS /	CUBIC	VOLUME/16.5-FT. LOG/SQ. FT. BA INTERNATIONAL 1/4	SCRIBNER	DOYLE
1	.682	12.1	59.9	53.3	37.7
2	.781	10.3	60.9	55.8	47.2
ALL	.738	12.3	67.8	61.5	48.9

STRATUM	AVERAGE D.B.H. /	CUBIC	VOLUME/16.5-FT. LOG INTERNATIONAL 1/4	SCRIBNER	DOYLE
1	13.836	14.1	70.0	62.3	44.0
2	19.341	21.6	127.5	116.9	98.8
ALL	15.484	17.8	98.0	88.8	70.7

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                          TEST  PAGE  21
CRC 8-04-80                                            2    400.  160      15467 123020
                   BOARD FOOT STRATUM SUMMARY FOR PRODUCT ST
```

STRATUM	GROSS VOLUME	PERCENT DEDUCTION	VOLUME DEDUCTION	NET VOLUME SCRIBNER
1	157822.4	1.9	3075.6	154746.9
2	280952.0	.0	.0	280952.0
ALL	438774.4	.7	3075.6	435698.9

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                    TEST  PAGE  22
CRC 8-04-80                                            2     400.   160     15467 123020
                      GRADE-YIELD AND REALIZATION REPORT
```

CLAS	GR	CU.FT.VOLUME	SQ.FT.SURFACE	LIN.FT.LENGTH	LOG FREQ.	COUNT
BS12	ST	9197.49	37835.12	13079.48	905.94	5
BS12	TW	423.02	3863.54	3720.61	362.38	2
BS15	ST	13017.96	52775.17	18141.31	3231.58	9
BS15	TW	8924.81	62039.73	36291.25	6845.18	12
BS15	XX	391.17	2192.41	978.06	144.68	1
C100	ST	9673.22	27806.59	6798.77	444.36	4
C100	TW	770.21	5092.75	3199.42	222.18	2
C66	ST	14656.39	42131.20	10301.17	444.36	4
C66	TW	1166.99	7716.28	4847.61	222.18	2
DIRE		13450.36	57628.86	21137.36	1050.30	12
DIRE	PW	12437.82	71221.91	33297.14	7084.50	6
RELA	ST	5319.79	21808.65	7688.63	617.34	3
RELA	TW	1386.08	10817.17	7475.06	411.56	2
TELR	ST	6317.40	16951.46	3976.39	804.92	6
TODI	ST	2778.32	7757.78	1729.11	288.19	2
TODI	TW	9731.04	37618.98	14132.30	432.28	3
TRAN	PW	4941.93	45637.42	42227.74	3594.45	6
TRAN	ST	20601.25	63332.05	18081.95	1927.68	19
TRAN	TW	851.41	4500.87	2581.79	285.58	3
ZEIS	ST	2549.31	7342.13	1687.49	281.25	2
ZEIS	TW	11262.19	42670.91	15468.49	562.50	4
TOTALS		149848.14	628740.80	266841.07	30163.37	109

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                                       TEST  PAGE  40
CRC 8-04-80                                                   2     400.  160       15467 123020
                   GRADE-YIELD AND REALIZATION REPORT BY DBH GROUP
                           CLASS  TRAN      GRADE  ST
```

DBH GROUP	VOLUME CU. FT.	SURFACE SQ. FT.	LENGTH FT.	LOG FREQ.	COUNT
16	2844.395	13098.571	4939.672	582.639	5
17	4367.983	13525.523	3441.590	473.758	5
19	2486.852	12284.362	5300.770	331.433	4
27	10902.018	24423.597	4399.924	539.850	5
TOTAL	20601.247	63332.053	18081.955	1927.680	19

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                        TEST  PAGE  52
CRC 8-04-80                                            2    400.  160      15467 123020
                          NUMBER OF TREES BY DBH GROUP
                                   CLASS TRAN
```

DBH GROUP	NUMBER OF TREES	BASAL AREA	PREDICTIONS	COUNT
10	283.58	154.67	14179.10	1
14	155.60	154.67	10580.84	1
16	225.93	309.34	18837.71	2
17	94.75	154.67	.00	1
19	82.86	154.67	.00	1
27	40.08	154.67	2204.34	1
TOTAL	882.80	1082.69	45801.99	7

Figure 80, continued

```
DENDROMETRY EXAMPLES AND OPTIONS                                          TEST  PAGE  54
CRC 8-04-80                                              2     400.  160     15467 123020
                                      NUMBER OF TREES
```

CLASS	NUMBER OF TREES	BASAL AREA	PREDICTIONS	AVERAGE DBH	COUNT
BS12	701.92	618.68	42405.85	12.52	4
BS15	5581.99	773.35	107961.43	3.62	5
C100	362.75	309.34	18769.96	11.79	2
C66	352.55	464.01	25379.25	15.32	3
DIRE	690.20	773.35	20079.36	13.95	5
RELA	311.32	309.34	19206.00	13.31	2
TELR	1286.40	618.68	15858.15	7.18	4
TODI	269.02	309.34	19855.78	14.29	2
TRAN	882.80	1082.69	45801.99	14.45	7
ZEIS	3038.43	309.34	50065.21	3.53	2
TOTAL/AVERAGE	13477.38	5568.12	365382.98	6.60	36

Figure 80, continued

DENDROMETRY EXAMPLES AND OPTIONS   TEST PAGE 62
CRC 8-04-80   2   400. 160   15467 123020

LOG DISTRIBUTION REPORT BY LOG TOP DIAMETER
CLASS TRAN   GRADE ST

DIA GROUP	BOARD-FOOT VOLUME INTERNATIONAL	SCRIBNER	DOYLE	VOLUME CU.FT.	LENGTH FT.	LOG FREQ.	COUNT
6	1437.226	1005.838	354.250	276.526	1199.291	82.858	1
7	4092.652	3034.086	1277.645	1419.204	2622.007	177.610	2
8	5277.521	4371.613	2268.906	955.399	2461.414	199.386	2
9	10573.017	8752.630	5319.423	2490.505	3289.868	199.386	2
10	7417.597	6288.802	4100.893	1716.243	1922.708	116.528	1
16	5898.554	5921.797	5131.289	823.867	623.341	94.752	1
17	18457.806	17055.760	14991.624	2445.235	1563.401	94.752	1
18	10801.067	10771.792	9860.706	1495.110	836.913	107.970	1
20	30054.963	28184.873	26352.883	3859.168	1781.506	107.970	1
21	34091.474	32109.438	30601.580	6273.487	1781.506	107.970	1
TOTAL	128101.875	117496.827	100259.196	21754.745	18081.955	1289.181	13

Figure 80, continued

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BOARD-FOOT VOLUME SUMMARY

CLASS	GR	BOARD-FOOT VOLUME INTERNATIONAL	SCRIBNER	DOYLE	VOLUME CU.FT.	LENGTH FT.	LOG FREQ.	COUNT
BS12	ST	54796.981	47458.016	32977.572	9348.496	13079.461	905.938	5
BS15	ST	65641.234	59100.363	39904.072	13396.924	18141.305	1761.458	6
C100	ST	56972.754	52124.911	43663.844	9964.925	6798.771	444.364	4
C66	ST	94342.204	86543.767	73757.910	14608.727	10301.167	666.546	6
RELA	ST	23298.719	19535.636	11921.596	5610.697	7668.634	617.336	3
TELR	ST	23992.604	21559.129	16464.466	7167.162	3976.391	268.306	2
TODI	ST	19146.854	18251.607	15854.767	3035.635	1729.111	144.093	1
TRAN	ST	128101.875	117495.627	100259.196	21754.745	18081.955	1289.181	13
ZEIS	ST	17558.534	16704.171	14333.788	2772.097	1687.488	140.624	1
TOTAL		483851.750	438774.414	349137.203	87659.406	81484.301	6237.845	41

APPENDIX 5.—LIMITING DISTANCE TABLES

LIMITING DISTANCES FOR 10 FACTOR PRISM
HORIZONTAL

DBH	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
					FEET					
5	13.75	14.02	14.30	14.57	14.85	15.12	15.40	15.67	15.95	16.22
6	16.50	16.77	17.05	17.32	17.60	17.87	18.15	18.42	18.70	18.97
7	19.25	19.52	19.80	20.07	20.35	20.62	20.90	21.17	21.45	21.72
8	22.00	22.27	22.55	22.82	23.10	23.37	23.65	23.92	24.20	24.47
9	24.73	25.02	25.30	25.57	25.85	26.12	26.40	26.67	26.95	27.22
10	27.50	27.77	28.05	28.32	28.60	28.87	29.15	29.42	29.70	29.97
11	30.25	30.52	30.80	31.07	31.35	31.62	31.90	32.17	32.45	32.72
12	33.00	33.27	33.55	33.82	34.10	34.37	34.65	34.92	35.20	35.47
13	35.75	36.02	36.30	36.57	36.85	37.12	37.40	37.67	37.95	38.22
14	38.50	38.77	39.05	39.32	39.60	39.87	40.15	40.42	40.70	40.97
15	41.25	41.52	41.80	42.07	42.35	42.62	42.90	43.17	43.65	43.72
16	44.00	44.27	44.55	44.82	45.10	45.37	45.65	45.92	46.20	46.47
17	46.75	47.02	47.30	47.57	47.85	48.12	48.40	48.67	48.95	49.22
18	49.50	49.77	50.05	50.32	50.60	50.87	51.15	51.42	51.70	51.97
19	52.25	52.52	52.80	53.07	53.35	53.62	53.90	54.17	54.45	54.72
20	55.00	55.27	55.55	55.82	56.10	56.37	56.65	56.92	57.20	57.47
21	57.75	58.02	58.30	58.57	58.85	59.12	59.40	59.67	59.95	60.22
22	60.50	60.77	61.05	61.32	61.60	61.87	62.15	62.42	62.70	62.97
23	63.25	63.52	63.80	64.07	64.35	64.62	64.90	65.17	65.45	65.72
24	66.00	66.27	66.55	66.82	67.10	67.37	67.65	67.92	68.20	68.47
25	68.75	69.02	69.30	69.57	69.85	70.12	70.40	70.67	70.95	71.22
26	71.50	71.77	72.05	72.32	72.60	72.87	73.15	73.42	73.70	73.97
27	74.25	74.52	74.80	75.07	75.35	75.62	75.90	76.17	76.45	76.72
28	77.00	77.27	77.55	77.82	78.10	78.37	78.65	78.92	79.20	79.47
29	79.75	80.02	80.30	80.57	80.85	81.12	81.40	81.67	81.95	82.22
30	82.50	82.77	83.05	83.32	83.60	83.87	84.15	84.42	84.70	84.97

LIMITING DISTANCES FOR 20 FACTOR PRISM
HORIZONTAL

DBH	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
					FEET					
5	9.72	9.92	10.11	10.30	10.50	10.69	10.88	11.08	11.28	11.47
6	11.66	11.86	12.06	12.25	12.44	12.64	12.83	13.03	13.22	13.42
7	13.61	13.81	14.00	14.19	14.39	14.58	14.78	14.97	15.17	15.36
8	15.56	15.75	15.94	16.14	16.33	16.53	16.72	16.91	17.11	17.31
9	17.50	17.69	17.89	18.08	18.28	18.47	18.67	18.86	19.06	19.25
10	19.44	19.64	19.83	20.03	20.22	20.42	20.61	20.81	21.00	21.19
11	21.39	21.58	21.78	21.97	22.17	22.36	22.56	22.75	22.95	23.14
12	23.34	23.53	23.72	23.92	24.11	24.31	24.50	24.70	24.89	25.08
13	25.28	25.47	25.67	25.86	26.06	26.25	26.45	26.64	26.83	27.03
14	27.22	27.42	27.61	27.81	28.00	28.20	28.39	28.58	28.78	28.97
15	29.17	29.36	29.56	29.75	29.95	30.14	30.33	30.53	30.72	30.92
16	31.11	31.31	31.50	31.70	31.89	32.08	32.28	32.47	32.67	32.86
17	33.06	33.25	33.45	33.64	33.83	34.03	34.22	34.42	34.61	34.81
18	35.00	35.20	35.39	35.58	35.78	35.97	36.17	36.36	36.56	36.75
19	36.95	37.14	37.33	37.52	37.72	37.92	38.11	38.31	38.50	38.70
20	38.89	39.08	39.28	39.47	39.67	39.86	40.06	40.25	40.45	40.64
21	40.83	41.03	41.22	41.42	41.61	41.80	42.00	42.20	42.39	42.58
22	42.78	42.97	43.17	43.36	43.56	43.75	43.95	44.14	44.33	44.53
23	44.72	44.92	45.11	45.31	45.50	45.70	45.89	46.08	46.23	46.47
24	46.67	46.86	47.06	47.28	47.45	47.64	47.83	48.03	48.22	48.42
25	48.61	48.81	49.00	49.20	49.39	49.58	49.78	49.97	50.17	50.36
26	50.56	50.75	50.95	51.14	51.33	51.53	51.72	51.92	52.11	52.31
27	52.50	52.70	52.89	53.08	53.28	53.47	53.67	53.86	54.06	54.25
28	54.45	54.64	54.83	55.03	55.22	55.42	55.61	55.81	56.00	56.20
29	56.39	56.58	56.78	56.97	57.17	57.36	57.56	57.75	57.95	58.14
30	58.34	58.53	58.72	58.92	59.11	59.31	59.50	59.70	59.89	60.09

Figure 81.–Limiting distances for 10- and 20-factor prisms, horizontal.

APPENDIX 6.—SLOPE CORRECTION TABLES

Limits of percent slope	Slope correction factor	Limits of percent slope	Slope correction factor	Limits of percent slope	Slope correction factor
10.0		55.8		80.7	
	1.01		1.15		1.29
17.4		57.8		82.3	
	1.02		1.16		1.30
22.5		59.8		83.9	
	1.03		1.17		1.31
26.7		61.7		85.4	
	1.04		1.18		1.32
30.4		63.6		86.9	
	1.05		1.19		1.33
33.6		65.4		88.4	
	1.06		1.20		1.34
36.6		67.2		89.9	
	1.07		1.21		1.35
39.5		69.0		91.4	
	1.08		1.22		1.36
42.1		70.8		92.9	
	1.09		1.23		1.37
44.6		72.5		94.3	
	1.10		1.24		1.38
47.0		74.2		95.8	
	1.11		1.25		1.39
49.3		75.8		97.2	
	1.12		1.26		1.40
51.5		77.5		98.7	
	1.13		1.27		1.41
53.7		79.1		100.1	
	1.14		1.28		1.42
55.8		80.7		101.5	

Correction factor for steeper slopes is:

$$\sqrt{1 + \left(\frac{\text{Slope percent}}{100}\right)^2}$$

Figure 82. – Appropriate correction factors for basal area or volume per acre calculated from unadjustable angle-gauge tallies taken on a slope, where slope percent is measured at right angles to contour.

SOUTHERN FOREST EXPERIMENT STATION

U.S. FOREST SERVICE RESEARCH NOTE

Forest Service, U.S. Dept. of Agriculture

T-10210 FEDERAL BLDG. 701 LOYOLA AVENUE NEW ORLEANS, LA. 70113

REVISED CALCULATOR FOR BARR AND STROUD DENDROMETERS

Clement Mesavage [1]

With pasted-on scales, a slide rule can be used to field-check readings made with all models of Barr and Stroud dendrometers.

Since the Barr and Stroud dendrometer is not a direct-reading instrument, several types of aids have been developed for quick checks of distance, height, and stem diameters. Experience with these indicates that a slide rule, suggested by Grosenbaugh *(2)* and constructed by Bruce *(1)*, is the most effective alternative at this time. The experimental prototype is not durable enough for constant field use, however, nor is it graduated to accommodate the new model FP-15 Barr and Stroud dendrometer. This model has a vertical swing that extends beyond that provided by the present slide rule, and its inclinometer is graduated in terms of 1 + sine and 1 — sine, rather than in terms of sine alone.

The author collaborated with Bruce to design and construct scales that will more nearly meet field requirements and accommodate all Barr and Stroud models now in use. Like its predecessor, the new rule was prepared by modifying Grosenbaugh's BCLEX program *(2,* p. 47) so that an IBM 7040 computer would print out logarithms of slant range, diameter, and appropriate functions of T and F grad. The instrument parameters were changed to agree with recent revisions of the STX computer program *(3)*. These logarithms, and logarithms of cosines needed to compute horizontal distances, were plotted on scales about 36 inches long, then reduced for attachment to standard double-faced 10- or 5-inch slide rules. Printed on thin paper that is weather- and rub-resistant, the scales can be affixed to rule surfaces with rubber cement, and can be positioned for hairline accuracy. Sets, illustrated in figure 1, are available on request from the Southern Forest Experiment Station.

Scales labeled AA, AB, AC, and AD are attached to one side of a slide rule, and are used to convert T grad (the first setting) to slant distance and to calculate height and hor-

[1] The author is Forester, Division of Timber Management, National Forest System, USDA Forest Service. The slide-rule scales described here were devised largely while he was on the staff of the Southern Forest Experiment Station, USDA Forest Service, at Harrison, Arkansas.

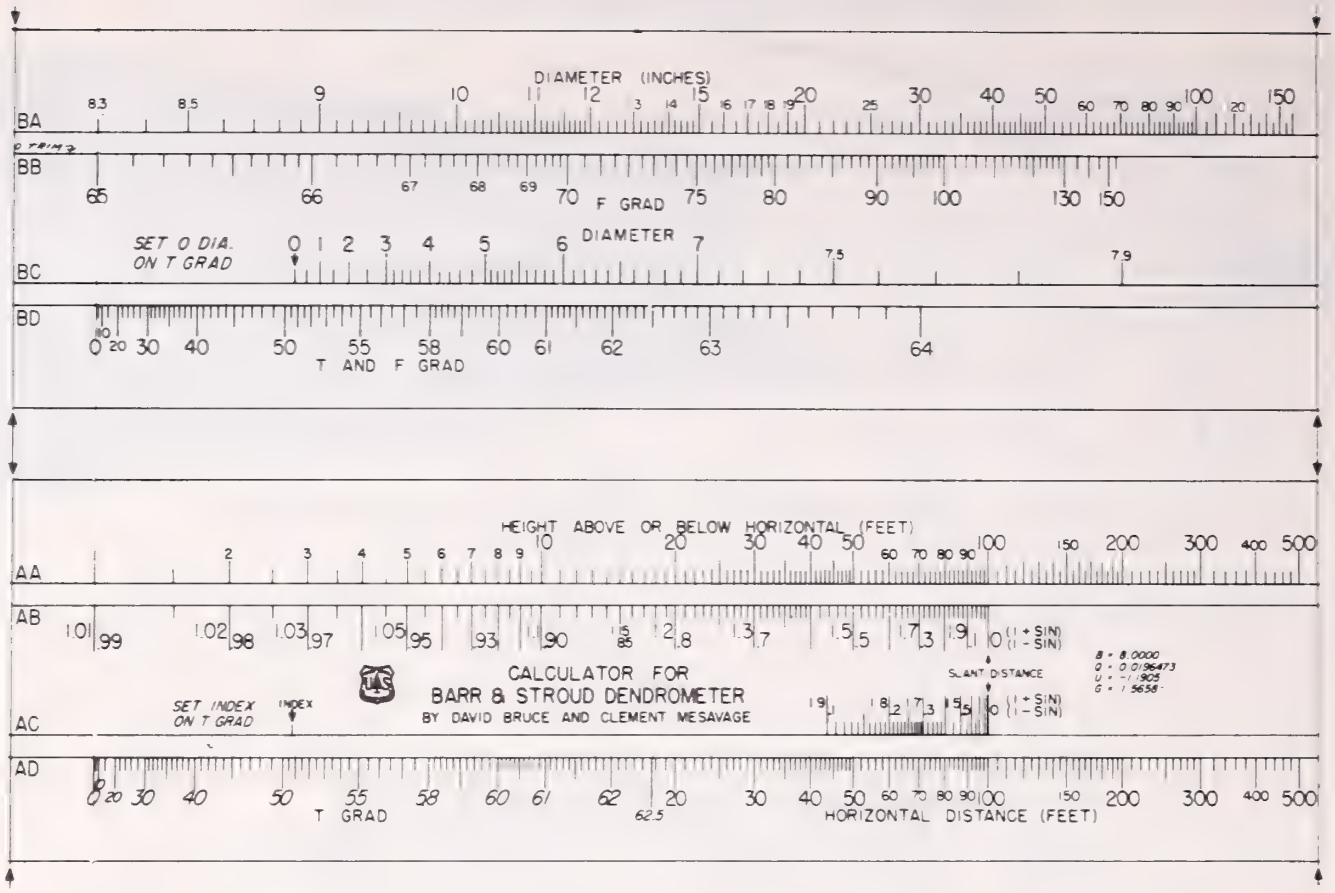

Figure 1.—*Scales for adapting a 5-inch double-face slide rule as a calculator for Barr and Stroud dendrometers.*

izontal distance for any elevation or depression of the line of sight. For example, the index on the AC scale shown by figure 1 is opposite a scale AD setting indicating a T grad of about 50.8. Slant distance is then read as 100 feet on scale AA opposite 0 on the AB scale. With a tilt of 40°, model FP-15 would show inclinometer readings of 1.643 for elevation and 0.357 for depression. For a T grad of 50.8, corresponding height would be read on scale AA as + 64.3 feet or — 64.3 feet. Horizontal distance would similarly be read on scale AD, opposite scale AC, as 76.6 feet for either of the above inclinometer readings. Since the inclinometers on models FP-9 and FP-12 are graduated directly in terms of sine, the vertical departure or horizontal distance correction would be read opposite 1 + sine scale for both elevation and depression.

The A scales are graduated for distances to 500 feet and heights 1 foot and greater above or below horizontal. Although 36 feet is the minimum slant distance that can be measured with the Barr and Stroud dendrometer, the scale for horizontal distance was extended downward to 18 feet to accommodate a slant distance of 36 feet with an inclination of 60°.

The B scales attach to the reverse side of the slide rule and are used for converting combinations of T and F grad to stem diameter in inches. With the index set opposite T grad, diameter is read opposite F grad on scale BC for F grads of 64 and smaller (stems 0 to 7.9 inches), and opposite F grad on scale BA for F grads of 65 and larger (stems 8.3 to 160 inches). Thus, for a T grad of 50.8, diameter would be indicated as 5.2 and 18.4 inches, respectively, for F grads of 60.0 and 80.0.

Scales BB and BC are proportioned to cover the upper two-thirds of the center bar so that the C scale of the underlying slide rule is exposed. If scale BD is positioned below the D scale on the lower rail of the underlying rule, the C and D scales are available for multiplication and division, either for bark thickness corrections or unrelated problems. Figure 2 shows the arrangement of the scales after mounting.

Accuracy of the slide rule is well within the tolerances claimed for the instrument itself. Diameters read from the 10-inch rule for a range of random settings correspond closely to diameters derived from tables supplied with the instrument, and are obtained more conveniently in less time.

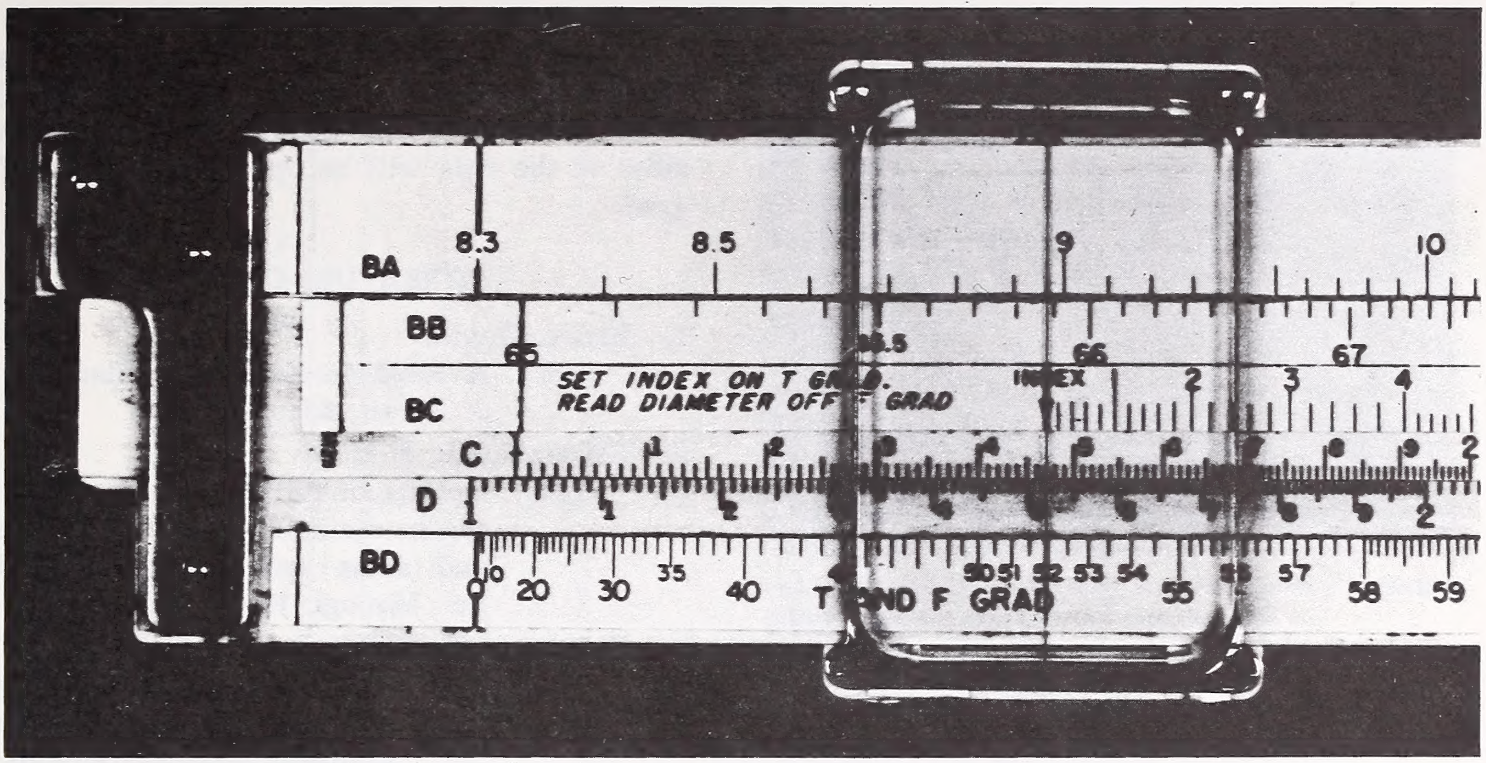

Figure 2.—*Scales BB, BC, and BD are positioned to leave exposed the C and D scales of the underlying slide rule.*

Although the slide rule is speedier than table lookup, its use with computer-processing should be confined to field checks, or to measuring trees where obstructed visibility may result in confusion and lead to undetected errors. STX computer processing will accommodate such direct measurements interchangeably with unconverted instrument readings if the tree input data card is punched appropriately, but field recording for a given tree must be on one basis or the other.

ATTACHING THE SCALES

The scales require a double-faced slide rule. The following procedure is suggested to assure accurate scale alignment and free movement of cursor and center bar.

1. Choose a rule that has ample clearance for the scale-paper stock and mounting adhesive. Test this by sliding two thicknesses of the paper stock strip under the cursor glass and under the end brackets on each side of the rule. If necessary, clearance for the glass can be obtained with shims. A slide rule requiring additional clearance through the end brackets should be avoided.

2. Before proceeding with scale attachment, adjust the rule so that the hairlines are aligned with the indexes on both sides. Fix the cursor in this position with a cardboard block and masking tape.

3. Slice the scales accurately along the scale line and trim to required width. Allow a margin of 1/16 inch at the outside edges of upper and lower rail scales. A sharp knife and steel straightedge are better for this purpose than conventional papercutters.

4. Starting with the center bar, slide the paper scale under the window glass until the index line is precisely under the hairline, and line up the scale with the side of the bar. Trim excess length to allow a margin of at least ½ inch on each end of the slide, but do not cut off the match lines. Hold the scale in this position with a stout paper clamp (fig. 3). Apply a thin, even coat of rubber cement to both the rule and scale surface to the right of the clamp. Allow a few moments for the cement to set, then press the scale to the rule, rolling it in place from the clamp out to the right end.

5. Remove the center bar, and attach the left side of the scale. Clean the bar and rail edges, and, if necessary, trim the scale so that the bar will again slide freely between the rails. Attach the right side of the scales to the upper and lower rails, in the same way, trimming length to fit between the end brackets. Clean and trim the scales so that the center

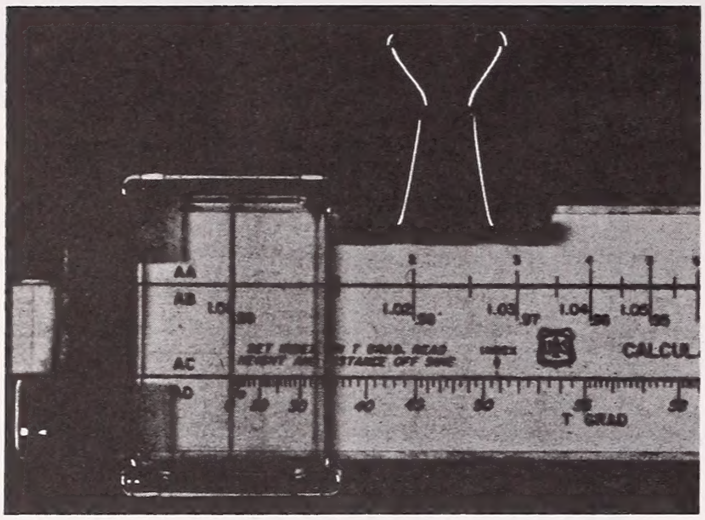

Figure 3.—*Shows cursor fixed in position with hairline adjusted to indexes of underlying slide rule, and paper scale overlay held in place before cementing.*

bar slides freely, then turn the rule over and repeat.

6. Release the cursor, and attach the left side of the scales to the upper and lower rails on both sides of the rule.

When the scales are aligned correctly, the match lines on the center bar will correspond with those on the rails, and the indexes on both sides of the rule will be opposite the same T grad.

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APPENDIX 8.—CALCULATOR FOR BARR AND STROUD DENDROMETER